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July 1936

TECHNOLOGY REVIEW

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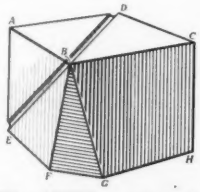
THE TABULAR VIEW

THE Review presents in this issue (pages 385 to 410) the complete proceedings of the Transportation Conference held at the Institute on Alumni Day, and gives you here a brief identification for each speaker. ¶ The Hon. John Monroe Johnson, who presided, has had experience as a civil engineer, and as an executive; he rose from sergeant in the volunteer infantry of the Spanish war to colonel of the Engineers, Rainbow Division, in the World War. From 1916 to 1917 he was chief engineer and chairman of the Marion County Highway Commission. ¶ Edward P. Farley is chairman of the executive committee of the American-Hawaiian Steamship Company, president of a ship-line company that bears his name, and director of the International Zeppelin Transport Company. He formerly served as chairman of the United States Shipping Board and as president of the Emergency Fleet Corporation. ¶ Edwin W. James, '07, Chief of the Division of Highway Transportation of the United States Bureau of Public Roads, has served in the Philippines and has been a member of the United States Engineering Corps. In 1926 he was technical adviser at the International Diplomatic Conference on Automobile Circulation and later was in charge of surveys for International Highway. ¶ Charles D. Young, Vice-President of the Pennsylvania Railroad, has been with that road since 1900. He is acquainted with their problems "from the ground up," having risen steadily to the executive position he now holds. ¶ Edgar S. Gorrell, '17, now President of the Air Transport Association of America, was sent to Europe by President Wilson as a member of the Balling Mission and has represented the United States in more than 200 international conferences. ¶ Joseph B. Eastman, Federal Coördinator of Transportation (this office expired on June 17), received this title in 1933. He is a member of the Interstate Commerce Commission.

COVER CLUB membership has not increased with the publication of this issue as we have used another photograph submitted by William C. West, '11, whose picture, "Translucence," appeared on the April cover. The view of the Chicago River used here shows, on the right bank, the Fisk Street Station of the Commonwealth Edison Company and, on the left bank, their Quarry Street Station.

THE solution to Professor Hudson's problem in the May issue of The Review (page 325) has been submitted by A. D. Smith, '04. If you haven't finished working on it, close your eyes: I DO NOT LIKE IT SAID THE MAN WITH THE BLACK TIE. THE RITE WE HAVE WITNESSED IS IMPRESSIVE BUT WHEN YOU INTER A MAN YOU RETAIN A CERTAIN POWER OF INVESTIGATION. THERE IS BOUND TO BE A REACTION AGAINST CREMATION WHEN THE IMPORTANCE OF THIS IS REALIZED. IF THE PRACTICE SHOULD PROVE TO BE AN IMPRECATION OTHER IMPRECATIONS MIGHT FOLLOW.



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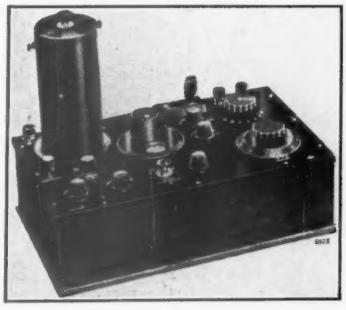

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1929	0
1930	0
1931	2
1932	4
1933	8
1934	1
1935	3
1936	6
	33

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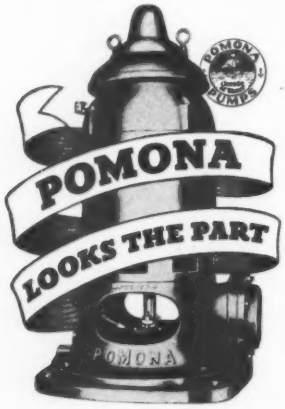

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MAIL RETURNS

Protest

From PROFESSOR L. MAGRUDER PASSANO:

If, in his interesting article in the May Review, "Science and the Fine Arts," Professor Hudson had limited himself to the statements of the title and subtitle, one could offer no criticism, but when he speaks of science as an inspiration of art one must, in the interest of truth, protest.

No one would deny that some scientists, perhaps as many as of ordinary men, have a true appreciation of art. But it is not wise for Professor Hudson to cite the long list of Technology men who have distinguished themselves in the arts to prove his thesis. They may well have been congenital artists whom a scientific education could not change or spoil — round pegs that succeeded in pulling themselves out of square holes. Leonardo da Vinci, perhaps the world's most universal genius, was a painter, musician, poet, and scientist in the order named. Lewis Carroll is far better known to fame than Charles L. Dodgson, the latter name being hardly more than an unfamiliar alias. Professor Hudson himself asserts that Sir Joshua Reynolds inspired the inventor Edison. On the other hand, if the science of the astronomer, Simon Newcomb, inspired his poetry, the result was shown chiefly in the *abundance* of his verse.

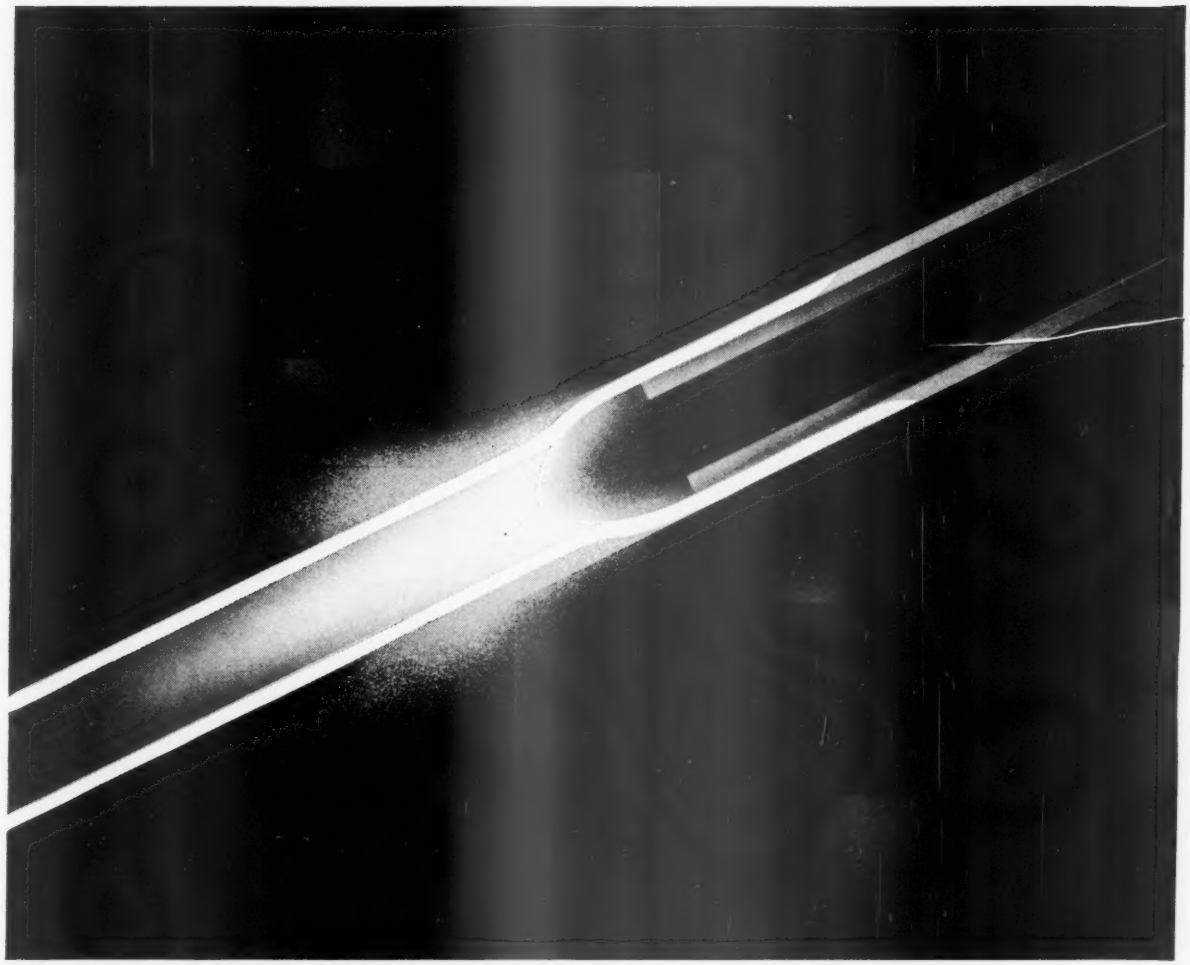
Professor Hudson surely delimits the avenues of approach of beauty too narrowly. Taste and smell may be discarded, but not touch. Any connoisseur will want to touch, to feel the texture and form of a Chinese vase, and many have the same impulse toward an ivory carving, a fine textile, or even a bronze or marble statue.

Science is ancillary to art. It is a servant helping art to achieve its ends. When carving is done by machinery, endlessly producing replicas of a pattern, like "gas pipe" suitings, one feels that the servant has left her station; that art will have married his cook. Science may also interpret art. The artist put the transverse arm of the cross where it looked best, just as he made his columns swell toward the middle in order that they might appear straight. The scientist wished to know where that "golden section ratio" lay. One of the simple rules of proportion told him. Thus: in the figure $\frac{A}{y \quad x}$, y and x are the shorter and longer portions of the vertical arm of a cross. The horizontal arm crosses at A. Choose A so that $y/x=x/x+y$. Thus $x/x+y=.618=21/34$ths. Having based the artist's choice of position upon a scientific theorem, the scientist can now see the beauty of the artist's work, and will henceforth insist that all crosses be made (by machinery) in exactly the same way, whether they stand on the summit of a spire or lie on the pavement of a crypt. All crosses — even the swastika — "look alike to him," provided they are scientifically made. Thus science inspires art!

The aim of art is to know, and to know what to tell — by word, by tone, by color, by form, by symbol — with wisdom as a guide and beauty as a goal. The aim of science is to know — and tell — everything about everything. "Paint what you see as you see it" is old-fashioned and discarded, replaced by "the cubistic 'Nude Descending a Staircase'" (based, by the way, on science) which tells more. These, and all schools of painting, are now to be discarded because "the camera sees so much better," and so much more, that it is to be the "art of the future," helped out by oil paintings made by spraying or by brushes revolved by machinery. Our grandchildren may look forward to exhibitions of pictures made by a combination ordinary-infrared-x-ray camera showing everything, an "all-together" that would make even Trilby blush and drive our highly moral censors insane.

One need hardly advert to the motion picture as a form of art, but a word or two seems due to the scientific music of the future. The art of music is to "be broadened if not revolutionized" by "electrical instruments," aided by a wonderful little thing called a decibel meter, and a "new type of artist must be developed to bring out the most pleasing tones" of a mechanical, electrical instrument. The apotheosis of the organ grinder.

What of poetry, the highest of the arts? One is told that "the effect of poetry is always a gamble," and Professor Hudson proceeds to gamble with a variation on a theme by Emily Dickinson. The gamble doesn't win. One need not defend Emily Dickinson, and one cannot defend her parodist. In a scientifically inspired (*Concluded on page 422*)



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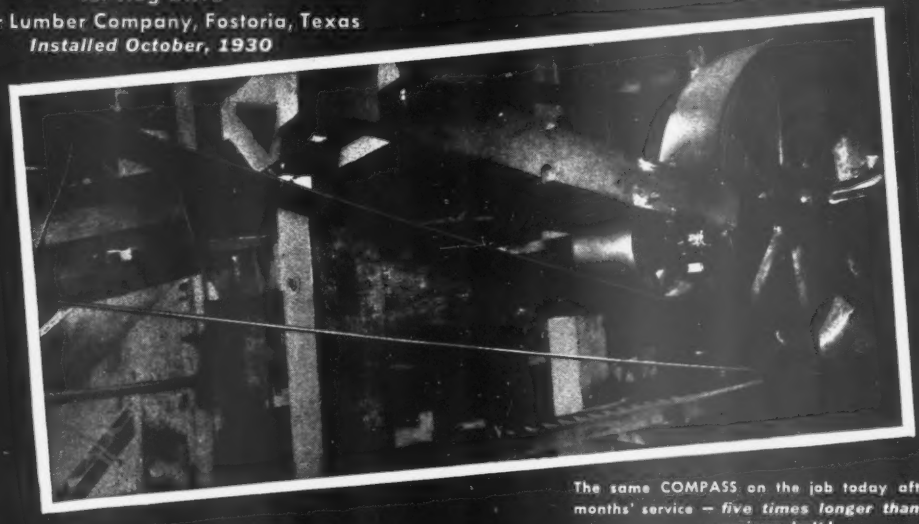

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THE TECHNOLOGY REVIEW

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EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Relating to the Massachusetts Institute of Technology

Editor
J. Rhyne Killian, Jr.

Tenney L. Davis

Publisher
Harold E. Lobdell

Editorial Associates
John J. Rowlands

Business Manager
Ralph T. Jope

John Ely Burchard

PUBLISHED MONTHLY FROM OCTOBER TO MAY INCLUSIVE AND IN JULY ON THE TWENTY-SEVENTH OF THE MONTH PRECEDING THE DATE OF ISSUE AT 50 CENTS A COPY. ANNUAL SUBSCRIPTION $3.50; CANADIAN AND FOREIGN SUBSCRIPTION $4.00. PUBLISHED FOR THE ALUMNI ASSOCIATION OF THE M. I. T. EDWARD L. MORELAND, PRESIDENT; MARSHALL B. DALTON, C. A. SAWYER, JR., VICE-PRESIDENTS; CHARLES E. LOCKE, SECRETARY; J. RHYNE KILLIAN, JR., TREASURER.

PUBLISHED AT THE RUMFORD PRESS, 10 FERRY STREET, CONCORD, N. H. EDITORIAL OFFICE, ROOM 11-203, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE A, MASS. ENTERED AS SECOND-CLASS MAIL MATTER AT THE POST OFFICE AT CONCORD, N. H. COPYRIGHT, 1936, BY THE ALUMNI ASSOCIATION OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY. THREE WEEKS MUST BE ALLOWED TO EFFECT CHANGES OF ADDRESS. BOTH OLD AND NEW ADDRESSES SHOULD BE GIVEN.

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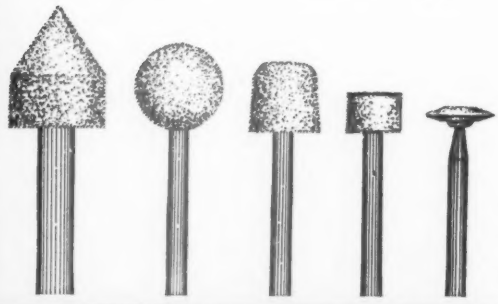

NORTON ABRASIVES

THE
TECHNOLOGY
REVIEW

Vol. 38, No. 9 July, 1936

The Trend of Affairs

Silver for Industry

WHILE silver has long been one of the noble metals, with a social and monetary "caste," its plebeian use in industry has come almost too slowly to bolster its tottering aristocracy. Research, however, now promises to give silver a new and more important place in the world of metals.

Its curious position as a metal, the conditions that surround its production, and some of the new uses to which it is being put were described by Lawrence Addicks, '99, in an authoritative paper presented at a recent meeting of the Mining and Metallurgical Society of America. Silver is forced upon the market by the silver producers, instead of being allowed to accumulate like copper, lead, and other metals in periods of economic distress. About one half of the total production of silver is as a by-product of other ores, and about 40% of all the silver produced in the history of the world is still on hand and therefore available — at a price. The production to date, according to Mr. Addicks, has totalled 15-billion ounces, so that six-billion ounces remain to challenge the application of science.

This country normally consumes some 30-million ounces of silver, of which one third is used in photography. Of the photographic silver, with Hollywood the chief consumer, a large part is recovered from the ash of burned films; even developer, when exhausted, is made to give back much of its silver by the use of treating plants attached to the darkrooms. Another third of the output goes into silverware, and this also comes back to the smelter with the changes of fashion and the settlement of estates. Other ordinary uses include perhaps two-million ounces. Mr. Addicks concluded that we ought to consume in this country not a mere 30-million ounces, but 125-million ounces.

Recent research work, looking toward an increase in silver consumption, has been divided under four heads: silver alloys, especially those which are silver-poor; the physical properties of silver; the chemical properties of silver; most novel and intriguing, perhaps, of them all, value of silver as a destroyer of bacteria. Silver can prevent bacterial action where such action is not wanted, for, if silver or metallic silver ions are introduced into water in the proportion of one part in 10 million, it will very rapidly sterilize the water.

Mr. Addicks discussed this bactericidal use of silver for public water supplies and swimming pools, mentioned a pocket-sized silver sterilizer for travelers in the tropics, referred to the use of silver in purifying aquariums, told of silver-sterilized ice, suggested a nonirritant soap containing a silver salt, and stressed the fact that silver-lined containers are considered best for fruit juices. Incidentally, he mentioned that vinegar will keep indefinitely in a silver-lined container, and that wines and beers in such containers suffer no deterioration.

Silver-sterilizing spray improves the quality of tobaccos, and a German hospital has formally stated that a bolus in which silver had been mixed cured tonsilitis when enfolded in the crypts of the tonsils. External sterilization of wounds through the use of silver was yet another medical use to which Mr. Addicks made reference, recalling that the Egyptians used silver plates on wounds to promote healing.

As substantial possibilities for the use of silver he mentioned silver-alloy bearings for automobiles, which are made of cadmium and a small quantity of copper with from three quarters of one per cent to one-and-three-quarters per cent of silver added.

Lighter storage-battery plates, silver silicon, silver-hardened tin, silver sulphide as a conductor of electricity, silver commutators on automobiles — all were spoken of

William E. Davidson

Above. *Tower of the San Francisco-Oakland Bay Bridge silhouetted against an early morning sky. Stiffening trusses may be seen suspended from the main cables, and the traveler filling in deck steel*

Below. *Cape Cod Canal by night and one of the beautiful bridges designed by Fay ('93), Spofford ('93) and Thorndike*

as promising uses of silver, while the thermal conductivity of silver was emphasized as a fact important to those interested in the equalization of furnace temperatures.

Cancer Campaigns

CANCER in the United States ranks second as a cause of death and its yearly cost to the American people has been estimated at the colossal figure of $800,000,000. The battle to conquer the scourge is being waged on a thousand fronts, and as the terms of the problem are narrowed by a truly stupendous accumulation of facts, researchers must surely be coming closer and closer to victory. Two or three recent developments, in fact, point toward an advance in knowledge that may be of lasting importance. That the task of research may be more direct than we have thought was indicated in February when Dr. Francis Carter Wood, director of the Crocker Institute of Cancer Research at Columbia University, suggested that the search for the cause may be narrowed to a comparatively small number of agents "responsible for many types of animal and, possibly, human cancer." Though the task of finding the cause will not necessarily be rendered any less arduous by the suggested limitation of possibilities, it will be clarified somewhat if Dr. Wood's belief is confirmed. The great variety of cancerous growths has in the past occasioned belief that the number of causes might be equally great. One parasitic worm has produced 18 varieties of tumor in rats, however, and chemical substances which have been used experimentally to produce cancer, it is reported by Dr. Wood, "bid fair to produce an equal or larger number."

In 1775 an English physician observed that the cancer prevalent among chimney sweeps was caused by soot, and in 1915 two Japanese scientists, by repeatedly painting the ear of a rabbit with tar, induced there a cancerous growth. These widely separated discoveries established coal tar (or some of its derivatives) as a causative agent in certain types of cancer, and provided the investigator with a method for the experimental production of cancer in laboratory animals.

They also posed a problem for the organic chemist: Is there some common denominator, perhaps of molecular structure or some other chemical relationship, among the various cancer-producing coal-tar compounds that have been discovered in his laboratory? There is yet no assurance that such a common factor, present in these compounds, can be found, but chemists are at work on the problem.

The baffling hunt for the cause of cancer may have been given new and more nearly correct direction by these findings, but no basis for prediction of the early discovery of a cure has been set up by it as yet. Setting one disease to fight another, as has been done in some other fields, was, however, reported by Dr. Mendel Jacobi of the Beth-El Hospital in Brooklyn as possessing effectiveness in experimental work on cancer. Injections of a diluted filtrate of the typhoid bacillus were used by Dr. Jacobi to treat animals having tumors chosen for their "high growth energy and degree of malignancy." The filtrates were first injected directly into the tumor, and about a day later a general injection was made through a vein of the abdominal wall. In the 70 animals thus treated the tumor began to break up within a few hours and finally disappeared. The local injection, it was found, must be made first, and neither injection is effective if used alone. Although the method was used in one human being, already moribund with a hopeless

A. S. Beale, '13

cancer, and was shown by autopsy virtually to have destroyed the cancer tissue, much more work must be done before the usefulness of the treatment in human cancer will be ascertained.

Our Diffident Dictator

HE who pays the piper calls the tune," runs the old adage, and American business adds smugly: "The customer is always right." From these propositions, design of consumer products for sales appeal follows naturally. Thus, artist-engineers who skillfully alter the appearance of such articles as domestic appliances, sanitary accessories, and business machines so that they are not only suited to the buyer's convenience but also to his idea of art, have received wide publicity and the approval of both businessman and customer. Nor is the engineer particularly affected so long as this expression of consumer control confines itself to making colored toilet seats of mother-of-pearl finish for the Mexican trade, but the engineer is not so sure of his peace of mind when he regards such a product of consumer control as the automobile, as Dean A. Fales, '14, pointed out in the April issue of The Review (page 276). Even dismissing from the discussion design factors affecting the primary question of safety, the engineer would find it difficult to justify such an addition to a pleasure vehicle as a supercharger on any technical or economic grounds. As the sales manager would probably admit in a candid mood (if sales managers experience candid moods), the supercharger is intended not so much to boost engine power as it is to boost the driver's ego.

However, the control of that supposedly humble and neglected individual, the consumer, often builds up more complex, if less disturbing, ramifications. Consider, for example, that gadget, the electric clock. Its advent meant only a minor addition to central-station load, but its widespread use forced radical changes in the operation of electrical power systems — primarily with respect to frequency control. Its effectiveness as a stimulus to continuity of service also, has, been far out of proportion to its current consumption. Only a short time ago, except in large cities, the quality of electric-current service during the early hours of the morning was of concern mainly to those few who kept such unholy hours. When service failures occurred the public utilities could disregard scattered protests of these few with impunity, but when droves of householders began to arise in the morning to find their synchronous clocks stopped or the "absolutely" correct time incorrect enough to make them miss their trains, their combined wrath made central stations take remedial measures.

Thus the consumer's yearning for electric clocks, plus the greater interconnection of power systems in the interests of reliability, have made the utilities devise extremely sensitive governors for the control of frequency. So that the $2.15 kitchen clock may stay on time, the speed of a 150,000-kilowatt turboalternator is kept steady to within $\frac{1}{25}$th of one per cent.

The attention that has been given to smoke and fly-ash control in recent years is basically a product of public pressure, for in many cases the changes which power plants have introduced in order to control this nuisance are not justified by economic considerations. Most modern central stations now scrub and wash their flue gases as carefully as a housewife does her laundry, but at considerably greater expense. In the case of pulverized coal there is sometimes a partial return, for the recovered fly ash can be used in making concrete. Not only are elaborate separators and precipitators installed, but also, in the case of old equipment, changes in boiler settings and fuel-handling equipment are often necessary. A cursory study of the literature will reveal how extensive (and expensive) have been developments in the handling of stack emissions. (Ironically, most of the pollution of the atmosphere by smoke and ash comes from domestic heating systems.)

William C. West, '11

Twilight in Chicago

There is another change in consumer buying habits that is interesting the power engineer. Within the past decade there has been an enormous increase in the number of electrical appliances used in the average home. Refrigerators, washing machines, ironers, and, still rather slowly, air-conditioning apparatus are all adding to the residential current load. From the strain that is being put on the distribution systems in resi-

dential districts and on the wiring of individual houses, there are resulting improved technical treatment of low-voltage networks and relatively inexpensive methods of adding to capacity of wiring in houses finding their electrical systems overstressed. One annoying symptom of overloading is the burning out of the usual plug fuses with distressing frequency, so there has been developed a type of thermal circuit breaker suitable for homes.

Two more instances may suffice: The petroleum industry is noting with great satisfaction that its fastest growing market increased its consumption by 17% last year. That market was the domestic fuel-oil field. The number of houses heated by oil has doubled in the past six years. When it is considered that 85% of the country's power-producing machinery is represented by its 26,000,000 road vehicles, and that the amount of oil burned by central stations is practically static, if not decreasing — for increased demand for electricity is met by greater efficiency in equipment — the influence of the domestic market in the oil industry can be imagined. The two most significant technical advances in oil refining during the past decade have been, probably, the introduction of polymerization and volatility control in the manufacture of gasoline.

Is a locomotive a "consumer product"? Whether it is or no, the railroads are certainly treating it as one. As the design of locomotives recently built or now building indicates, there is a considerable trend toward streamlining, determined in large measure by what the railroads consider as pleasing to the esthetic taste of the public.

In no country on earth does the engineer bend as willing an ear to the whims, the desires, the needs of the public as he does in the United States. On the whole that ready yielding, or rather catering, to consumer demands has been an important factor in creating the material comfort that marks American life. Sometimes the results are of dubious value, as in the "streamlining" of refrigerators and locomotives; occasionally, as in the case of the automobile, the buyer definitely does not know what is good for him. Nevertheless, in the future as in the past, industry will continue to chant: "Praised be that diffident dictator, the American public."

To Down Dusty Death

DEATH disguised in particles of dust so minute as to be invisible must test its mettle against that of the Federal government represented in a committee of 53, named by Frances Perkins, Secretary of Labor, to work out plans for the control and termination of silicosis as an industrial hazard.

Nearly the entire population of the country breathes in small particles of dust containing silica, the inhalation of which causes the disease. That the whole population does not suffer from silicosis, however, results from the fact that the lungs appear to have a tolerance of at least 0.217% of rock dust, for Drs. T. H. Belt, D. Irwin, and E. J. King of the University of Toronto have shown that the dried lungs contain this proportion of silica. The disease itself does not occur until the content of silica reaches five per cent and the lungs show signs of fibrosis. Why the smaller amount which nearly all persons must accumulate from street and household dust does not have a malign effect is not known.

Workers in mines, quarries, foundries, glass factories, and other industries where the inhalation of silica dust is likely — and there are about a half million of them — may readily, however, breathe in the perilous five per cent. The most dangerous particles are those so small that they are invisible as dust; these may reach the small air cells of the lungs and cause irritation by penetrating the lining membrane. The replacement of healthy tissues by fibrous or scar tissues results. Shortness of breath, early fatigue, and general indisposition, with occasionally visible symptoms, follow; diagnosis, however, usually requires x-rays. Tuberculosis and pneumonia inevitably result from silicosis.

Miss Perkins' appointment of engineers, health experts, and representatives of workers, insurance companies, employers, technical societies, and the government to determine methods for ending this incurable disease is recognition by the nation of the size and importance of the problem. Conditions which were said to have prevailed during the boring of the Hawk's Nest power tunnel at Gauley Bridge, W. Va., and which were made worse by rumor, resulted in investigation of the situation by Congressional authority.

Science Service

Professor George R. Harrison of Technology's Department of Physics and his automatic wavelength measuring, computing, and recording machine now being used in gigantic, systematic determination of wavelengths and intensities of the spectral lines of the elements

Both the state and the city of New York, likewise, have been concerned over the danger. About 20,000 workers in the state and about 4,000 in New York City are exposed in their work to the hazards of silica and other dust. Many damage suits have been brought by sufferers who were not protected by workmen's compensation laws — one of the more recent asking damages of $100,000. Commenting on this phase of the situation, Miss Perkins said: "An extremely expensive economic situation ensues if everyone who acquires silicosis can bring a damage suit. There has been, therefore, considerable canvassing of the laws and of methods by which this disease can practically be brought under workmen's compensation laws."

Economic, legal, and insurance phases of the problem, covering the cost of combating it are one of the four lines of attack which Miss Perkins' committee will follow. V. P. Ahearn of Washington heads the section which will consider this aspect. Dr. P. R. Sayers, surgeon of the Public Health Service, is in charge of the section concerned with the medical phase of the situation; Warren A. Cook of the State Department of Health, Hartford, Conn., the engineering; and L. Metcalfe Walling, Labor Commissioner, Providence, R. I., regulatory and administrative. The medical section will be concerned with catching the disease in incipient stages and so fighting it. Engineering control will seek to determine methods of equipping plants so as to prevent conditions conducive to the disease — work which will involve special types of ventilation designed to collect the dust at the point of origin and prevent its escaping into the workroom, wetting down processes, and the use of masks. The regulatory phase of the problem includes the devising of regulations to govern plants liable to an outbreak of the disease.

Science Service

Dr. Hammond V. Hayes, '85, veteran Boston electrical engineer, adjusts his new type of radiation receiver, which is more sensitive than photoelectric cells or the best vacuum thermocouples, for invisible infrared rays. The device makes possible signaling with invisible light. The rays are caught by the concave mirror at the left above and focused on the small cylindrical receiver. Electricity from the receiver runs through a shielded cable to an amplifying set where, finally, the signal is read with the microammeter on which Dr. Hayes's hand rests

Fruits of Research

ANYONE who questions the value of intelligent research would find a convincing answer in the amazing number of developments, inventions, and improvements in various fields that come to the attention of The Review Editors every month. It is no exaggeration to say that every issue could be filled with news of advances in science and engineering that are the fruits of investigation based on careful study of requirements, the economic necessity for using hitherto valueless by-products, and the wholesome urge to create.

From the mass of material at hand we choose those that have special interest at the moment, developments having immediate applications, and those which hold high promise for the future.

¶ General Electric research engineers have developed a turbine generator which will be the first to make use of hydrogen as a cooling medium. Built for the Appalachian Electric Power Company at Logan, W. Va., this 40,000-kilowatt generator is unique in several respects: In addition to being hydrogen cooled, it will operate at a steam pressure of 1,250 pounds and a temperature of 925 degrees F., which is higher than any hitherto used in this country in a large turbine. Air friction and rotational losses have been largely eliminated by the use of hydrogen for cooling, and it is confidently expected that the new machine will operate efficiently at a speed of 3,600 revolutions per minute.

¶ Another development of General Electric research is a prerecording oscillograph which makes it possible to anticipate a phenomenon in order to get a photographic record when it occurs. This instrument may be used to record the phenomena associated with the discharge of lightening. In a sense, it uses memory as a substitute for foreknowledge. The recording element is a cathode-ray tube, and a pencil of cathode rays traces a record of what occurs electrically on a glass slate coated with a phosphorescent substance. When electrons strike this substance it glows with a brilliant green light which lasts for a fraction of a second. This action is, in effect, one of memory, and the instrument is thus prepared to record a phenomenon occurring instantly afterward. Originally designed for studying lightening, the prerecording oscillograph now has important uses in the study of power rectifiers and various types of electronic tubes.

¶ The Northern Illinois Coal Corporation recently placed in operation the world's largest power shovel. This Gargantuan digger has a capacity of 32 cubic yards, and in one bite it will lift enough earth to fill an ordinary room. In coal-stripping operations, where the

shovel is being used in handling earth, shale, and broken rock, the weight of the dipper load is 50 tons, and it is estimated that the machine will uncover well over 100,000 tons of coal a month. Operated by one man, the huge machine can pick up a load at working level and deposit it at a point 70 feet above.

¶ Coöperating with Dr. John M. Arthur of the Boyce Thompson Institute for Plant Research and the Westchester Lighting Company, General Electric engineers have developed a new type of greenhouse which is expected to facilitate the growth of out-of-season flowers, fruits, and vegetables. In contrast to the familiar greenhouse of glass, the new one is totally enclosed except for a single row of windows on one side of its roof. This development seems to bring nearer the possibility of the earthless gardens described in the April issue of The Review (page 262).

¶ A new type of shatterproof glass employing a rosin known as vinyl has been announced by the Mellon Institute of Pittsburgh. The new glass is said to be capable of stretching, and so strong is the vinyl bond between the layers that when completely shattered the fragments remain in place. A kicking mule, a football player, and a man with "an unbreakable head" played their parts in a public demonstration of this new glass, which is said to be less brittle than other types at very low temperatures.

¶ Because most of the gases used as refrigerants are virtually odorless, colorless, and tasteless, it is desirable to have some method of detecting leaks. The Linde Air Products Company has developed a device called Prest-O-Lite Halide Leak Detector. The device consists

H. E. Fletcher Co.

Quarrying granite in Massachusetts. Note the large core holes which permit inspection below the surface. Above is a compressor plant

of a needle-valve torch assembly, a burner with a suction nipple for attaching a rubber hose, and a chimney with a copper reaction plate. The open end of the suction tube is used in exploring for gas leaks and when any gas is drawn into the burner it decomposes, forming free acids. These acids in contact with the hot copper plate cause instant color changes in the flame. Needless to say, the instrument is for use in detecting noncombustible gases.

¶ One of the bugaboos of the printing industry has always been offsetting — the effect produced by a transfer of ink from a freshly printed sheet to the back of the adjacent one as they are stacked by the printing press. The research department of American Type Founders has developed a device which spreads a microscopic film of powder over each sheet as it comes from the press. A special type of spray gun was designed to apply the powder, which is said to have no effect on the desirable qualities of printed matter.

¶ From Germany comes news of the discovery of a method for making artificial pumice, which involves the use of volcanic glass, obsidian, which is preheated to a temperature of 1,652 degrees F., then dropped down a shaft furnace against a rising draft of hot gases. This treatment causes the material to swell into porous particles many times its original size. In this form it is consolidated with lime or cement for use as an abrasive.

Frank H. Trego

¶ The expedition now in India attempting an ascent of Mount Everest is equipped with eider-down garments made for the first time on the

Korth

Bottom of opposite page. *Yucca against a desert sky*
Left. *Nature's wood carving*

cube cell principle. The coating is not only extremely warm, but is also very light, its weight being less than three pounds per garment.

¶ A new type of mercury arc lamp, which operates at a temperature of 25,232 degrees F. — a heat more than twice as great as that at the surface of the sun — was recently demonstrated in New York by Dr. John W. Marden of the Westinghouse Lamp Company. Progress in improving artificial illumination along somewhat similar lines was announced at the same time by Dr. L. J. Buttolph of the General Electric Vapor Lamp Company, who described experiments with a new-type fluorescent mercury lamp. Using invisible ultraviolet to produce visible light of all colors, the fluorescent lamps furnish from 50 to 120 times as much visible light in return for the electrical energy used as ordinary incandescent lamps do.

Plywoods to the Fore

OUTSTANDING building materials development of the past year has unquestionably been the rise of resin-bonded plywoods. Plywoods themselves are far from new, the balanced stress principle having been known even by the Egyptians. All the present methods of cutting the plies of veneer, all the chief wet glues — tapioca, hide, casein, blood, albumen, soya bean — have also been known for long. Even the resin which now serves as the new binder, a resin of the phenol-formaldehyde or Bakelite type, is no novelty at all. Many manufacturers have experimented with the resin bonds for long enough to have some confidence in their present claims, but only during this year have enough presses been installed in the United States and sufficient capacity been created to warrant the assumption that resin-bonded plywood is actually on the march. It would be fallacious, however, to assume that it had reached its destination.

At present resin-bonded plywoods are available only in the finer and more expensive woods. Because of practical limitations of press capacity it is impossible at this time to make one piece of extraordinary length. Under the cold processes where the pressing was a long-time operation it was possible to advance the stock while pressing. The resin-bonding operation, on the other hand, is quick and must be done simultaneously. Hence the length of the plywood will be governed by the length of the press, which for cost reasons will usually be limited to 12 feet or less. Fortunately the manufacturers have developed a rather fine scarfing technique which forms a splice only 10% less strong than the unspliced board.

Chief advantages of the resin-bonded plywoods lie not in their greater strengths, which were not particularly needed, but in the quickness and cleanliness of the operation, in the fact that the glues are dry — hence the wood does not have to be redried, with the danger of establishing internal stresses — and, principally, in greater waterproofness. The cost of the glue film is negligibly greater than the cost of other good glues. Principal disadvantages lie in the close precision required in the manufacturing and, at present, in the price. If there is to be hope for cheaper and, hence, more widely usable resin-bonded plywoods, cheaper woods must be used. To all intents and purposes cheaper wood means Douglas fir — and herein lies a story.

Veneers may in general be cut by one of four methods. Sawn veneers are most accurate and have the best grains and strengths, but are seldom used because at least $\frac{1}{16}$-inch of wood must be wasted for each ply that is cut. Fine hard-wood plies are formed by slicing with a long and heavy knife from the flitch that has been

Lewis P. Tabor, '22

Mooring

steamed or boiled. Rotary cutting is, however, the cheapest method and about the only one that seems sensible to use with a cheap lumber like fir. This cutting is done on a lathe which permits the log to revolve against a knife. The grain figures produced are rather wild and ordinarily undesirable, but, as will be seen later, in most cases further finishing will in any event be needed.

Rotary-cut veneers are, however, by no means of uniform thickness. The cutting knife will spring more or less, depending upon the force needed to make the cut, which in turn depends upon the character of the wood, the local hardness or softness, and the sharpness of the knife. The log, too, will spring more or less and tends to spring more as its diameter decreases. Moreover, unless the lathes are kept in first-class condition, imperfect action of gear teeth and other mechanical defects cause irregular feed. Again, the operator in cutting veneers of the same nominal dry thickness may set the feed differently at different times. Finally, the veneer when cut is very wet — much wetter than is permissible at the time of gluing, and, on drying, the veneers by no means shrink to uniform thickness.

Under the old, cold-wet process of making plywood, which has accounted for practically all of the industrial plywood in this country, the thickness variation of the veneer layers made little difference. The veneers are used with little or no sorting, an inexpensive liquid glue is applied to alternate plies in liberal quantities, a large stack of boards is piled up, one atop the next, and the entire stack pressed at once. It is essential for good gluing that adequate and relatively uniform pressure be obtained in every part of every joint. Under the old process, however, the stack had a definite cushioning effect. The veneer was quite wet from the glue and, therefore, had a reduced resistance to compression; and the long time of pressing also contributed to equalize the pressures. The cold-wet process, therefore, could not be said to be sensitive to thickness variation.

Under the processes of gluing with thermosetting resins, however, all is different. These glue films are applied either as powders or as colloidal suspensions, or, most usually now, as preformed films. To cause adhesion the plies thus brought together with glue films between must be subjected to considerable pressure and temperature, and, moreover, to pressures and temperatures that must be kept within a rather narrow range. Since wood has a considerable virtue as a thermal insulator, it is evident that a stack may not be used. If the hot platens of the press are the right temperature to set the outer boards, those in the center of the stack will be too cold; if these are to be at the right temperature, the outer boards will be overheated. This makes it practically impossible to employ the averaging effect of the stack as was done in the cold-wet process. The plies are not wet and, hence, have a good compressive strength; the time of pressing is quite short, a matter of minutes rather than hours. Thus, on all counts, the thermosetting, resin plywoods must be sensitive to variations in veneer thickness. Yet these variations in the desired cheap-wood Douglas fir are great.

Two courses are open and both have been advocated. The simpler hope is to seek the same precision in cutting Douglas fir plies that has been achieved with other plywoods. There is probably nothing impossible about this, but it must be remembered that the Douglas fir plywood people have been set up for a long time on a mass-production, quantity-price basis which required no precision in cutting the veneers. An attitude cannot be changed over night. There may be doubt, moreover, as to whether the cost of more precise cutting would permit Douglas fir plies still to be rated as cheap wood. In any event it is unreasonable to expect stupendous developments in this way in a hurry. The Douglas fir people may take a hitch in their belts and oil up their calipers, or they may not. If they do, plywood manufacturers will then make the plywoods by the hot-plate method in which a hot steel plate, usually heated by steam, is interposed between each panel of plywood and those above and below. The technique of hot pressing is well enough developed when the veneers are received with reasonably close tolerances.

Other workers have despaired of accurate cutting and have devised an electric press which will permit stack formation and the consequent averaging of plies. This is accomplished by the use of thin and flexible hot plates made by imbedding an electric heater, about as thick as a piece of blotting paper, inside an asbestos pad, the whole being covered with face sheets of 20-gauge steel.

Even if, one way or another, fir plywoods might be made with thermosetting resinous bonds, neither fir nor most other coniferous woods can be subjected to the high bonding temperatures required, without developing numerous fine checks in the surface plies after the panels have been removed from the press and allowed to cool. These checks may well render the surface unfit for finishing by usual methods. Additional finishing might, therefore, be required. This would perhaps be required in any event for the real field of expansion of the resin-bonded veneers lies in out-of-door work. Old-type plywoods when well made have had an honorable history when they could be protected from the ravages of the weather.

Our favorite plywood theory today suggests making the outer plies very thin — say of the order of 1/28-inch thick. Such veneers when subject to outdoor conditions do check, but since the degree of checking is a function of the thickness, the checks are practically imperceptible to the naked eye. They will, to be sure, permit some penetration of water to the first glue layer, but all the manufacturers seem to be agreed that this glue layer will resist any further penetration of moisture.

The use of such thin veneers suggests interesting possibilities in house design. It might be feasible to use, as face veneers, expensive and exotic woods in plies so thin that the resin-bonding material of the first glue layer practically impregnated them. These woods could be used in their natural colors and grains. In many cases, however, it will be desirable to have a more fireproof panel. There are certain plywoods on the market with fireproofed cores so that they will pass the more moderate fire tests. But a more likely treatment might be to glue a sheet of asbestos-cement board to the plywood. Efforts to fasten exotic wood veneers to asbestos board are illuminating. It was found in this attempt that the glue bond was satisfactory, but that the asbestos fibers were pulled from the cement rather easily, so that the final bond was not satisfactory. This difficulty has ap-

parently been overcome by first treating the asbestos board with a urea-formaldehyde resin which seems to have the property of holding down the fibers, and then gluing the veneer on with a phenol-formaldehyde resin. This product was used rather extensively on the *Queen Mary*. A similar process might be employed to glue plywood and thinner sheets of asbestos cement together, using the weather-resistant asbestos board as the covering for the stiffer and cheaper plywood, instead of using a veneer as a decorative covering for the stiffer and fireproof asbestos board.

Considerable progress has been made with bonding metals to plywood. One such product is made up of a quarter-inch plywood board, covered on one side with a thin sheet of stainless steel and on the other with two-ounce electrolytic copper. These panels are by no means cheap at present, and sizes have to be watched because of the thermal-expansion problems raised by introducing metal, but they are used now to a considerable extent on streamline trains and in the paneling of truck bodies. Another interesting product that is not a plywood at all is made of a thin gauge metal to which a thin wood veneer, impregnated throughout with resin, has been bonded.

Whatever the exterior treatment, the edges of resin-bonded plywood are not immune from attack by moisture. Actual penetration of water through the thicknesses of the plywood can probably be prevented. At the edges, however, the entrance of water tends to cause an expansion which, although not breaking the bond, will tend to open the joint between adjacent sheets. This is a serious difficulty. In some cases it may be overcome by carefully worked out details of design. Perhaps it will be eliminated by coating the edges with new and promising thermolyzed tung-oil enamels, perhaps by further resinous treatments.

All of this furor assumes, of course, that the resin bonds are going to stand up for a long time under out-of-door conditions. The resin makers seem reasonably confident, and so do the plywood makers. It may be mentioned that with the exception of one or two out-door exposures of laminated bakelites, there has been little published evidence that the resins will stand up indefinitely. It may be recalled also that many of the resins seem to lose some of their properties with age. This much is certain: The resin-glued bonds are stronger, and all accelerated tests are in their favor.

It seems very likely, therefore, that plywoods will open virgin territory in the building field for many people. There seems no doubt that the resin-bonded products will become an important adjunct to industry. It may be just as well, however, at the moment, to keep optimism within bounds; to recognize that, promising as these products are, they are by no means perfected; to realize that up to the time of this writing they are definitely not cheap; to entertain for the time being, at least, some doubts as to their behavior—doubts which we may hope will prove unfounded.

Planning for the Future

A Reading List on the Rôle of the Technical Adviser in Industry and Government

COMPILED BY THE M.I.T. LIBRARY

ADAMS, J. T. and others. New England's prospect. American Geographic Society, 1933.

"Twenty-seven writers join hands to diagnose the industrial, agricultural, political, and social activities of New England." — *Book Review Digest.*

"For New Englanders it is an especially valuable publication, while for residents of other portions of the United States it will commend itself as a pattern for similar investigations elsewhere." — *American Economic Review.*

THE AMERICAN PETROLEUM INDUSTRY; a survey of the present position of the petroleum industry and its outlook towards the future. American Petroleum Institute, 1935.

"The Institute has considered it wise to bring the 1925 survey down to date, make a study of petroleum reserves, forecast demand, and broaden the scope of the original survey by adding chapters on transportation, refining, marketing, taxation, and labor." — *Preface.*

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS. Elements of a national mineral policy. The Institute, 1934.

"Deals with the economic consequences of nationalistic ambitions upon mineral trade, the open-door policy of mineral development, tariffs, national defense, international relations, influences of national planning, stabilization and control of production." — *Annals of the American Academy of Political and Social Science.*

BAUER, CATHERINE. Modern housing. Houghton Mifflin, 1934.

"Combines the lucidity and raciness that interest the layman with the completeness, grasp, and thoroughness that the expert requires." — *New Republic.*

BEARD, C. A. The open door at home; a trial philosophy of national interest. Macmillan, 1934.

"In his opinion, the United States should till its own garden and not cast envious eyes on foreign markets; the theories of Adam Smith belong to the premachine age, and today the magic of science can provide for the wants of the American people if only we insure the proper distribution of wealth." — New York *Herald Tribune Books.*

BEMIS, A. F. Rational design (Volume 3 of The Evolving House). The Technology Press, 1936.

Aims to analyze house structure, to state fully the terms of this important and pressing problem, and to present a logical solution in the redesign of man's shelter.

CHASE, STUART. Government in business. Macmillan, 1935.

"The rôle of government in business has been steadily expanding, both in Europe and America, and in recent years has reached an accelerative pace. It has expanded [the author holds] because it had to: because private enterprise has been either unable or unwilling, in one field after another, to do what had to be done." — New York *Times*.

CROWTHER, SAMUEL. America self-contained. Doubleday, 1933.

"Mr. Crowther holds that America is self-contained and should depend on her own resources, and formulate a system of national economy suited to her own needs." — *Book Review Digest*.

DIMOCK, M. E. Developing America's waterways; administration of the Inland Waterways Corporation. University of Chicago Press, 1936.

"From the points of view of economic justification and efficiency in management." — *Science News Letter*.

FLANDERS, R. E. Platform for America. McGraw-Hill, 1936.

"The author believes that modern technology plus private enterprise and liberal democracy have maintained a larger number of people at a higher standard of living than any other system which has ever existed in the history of the world. . . . This book seems to me the most reasonable and clear statement of the viewpoint of an intelligent industrialist which has come to my desk." — Dorothy Thompson (Mrs. Sinclair Lewis) in New York *Herald Tribune*.

GAYER, A. D. Public works in prosperity and depression. National Bureau of Economic Research, 1935.

"Best available information concerning the volume of public works undertaken by local, state, and Federal governments . . . and the numerous factors that bear upon efforts to use public works as an economic stabilizing device." — *Municipal Reference Library Notes*.

HART, J. K. Education for an age of power. Harper, 1935.

"Sets forth the dramatic impact of power development within such a limited area as the Tennessee Valley and portrays it both factually and creatively." — Western Society of Engineers *Bulletin*.

HAYNES, WILLIAM. Men, money and molecules. Doubleday, 1936.

"Popular history of the economics of our chemical industries by the editor and publisher of *Chemical Industries*." — New York Public Library *New Technical Books*.

ICKES, HAROLD LeC. Back to work; the story of PWA. Macmillan, 1935.

"Describes what is being accomplished particularly in the fields of slum clearance, development of water power, and improvement of roads and railroads." — American Library Association *Booklist*.

JESNESS, O. B. and others. Program for land use in northern Minnesota; a type study in land utilization. University of Minnesota Press, 1935.

"A notable contribution to land economics, land planning, and political science as related to land utilization." — *Journal of Farm Economics*.

LOEB, HAROLD and others. The chart of plenty; a study of America's product capacity based on the findings of the National Survey of Potential Product Capacity; foreword by Stuart Chase. Viking Press, 1935.

"The first attempt to apply the rationality of engineering and accountancy to the central problem of American life and economy, namely, the capacity of American technology to provide a decent standard of living for all the people in the United States." — C. A. Beard in the *New Republic*.

MATTHEWS, D. M. The management of American forests. McGraw-Hill, 1935.

"Deals with practical problems of management of forest property in the United States from both the technical and the financial standpoint." — *Preface*.

MILLER, S. L. Inland transportation: principles and policies. McGraw-Hill, 1933.

"In addition to the history of American railroad transportation, this volume analyzes motor, inland water, air and pipe-line transportation." — *Book Review Digest*.

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NEWMAN, B. H. The building industry and business cycles. University of Chicago Press, 1935.

"Discusses the factors which influence building activity, the relation of building activity to building cycles." — *Heating and Ventilating*.

POUND, ARTHUR. Industrial America; its way of work and thought. Little, Brown, 1936.

"Shows how corporation public policies and industrial relations practices improve the condition of the working classes and produce necessary services in a way and at a price to deserve general good will." — *Industrial Arts Index*.

PRESIDENT'S RESEARCH COMMITTEE ON SOCIAL TRENDS. Recent social trends in the United States. McGraw-Hill, 1933.

"Never before, to my knowledge, have so many major problems of a given time in a given culture been brought together, weighed, and documented with such precision and intelligence." — Stuart Chase in New York *Herald Tribune Books*.

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Makes specific recommendations for a national program for putting science to work for the national welfare.

UNITED STATES NATIONAL RESOURCES BOARD. Report on national planning and public works in relation to natural resources and including land use and water resources, with findings and recommendations. 1934.

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"Here is a careful study, and an urge to adequate agriculture as panacea and scientific regulator." — *Review of Reviews*.

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"Discussion of low-cost urban housing in England, Germany, and the United States." — *Book Review Digest*.

TRANSPORTATION

ITS PLACE IN THE NATIONAL ECONOMY, ITS PROBLEMS, AND ITS FUTURE DEVELOPMENT

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Photographs by F. S. Lincoln, '22, and the United States Bureau of Public Roads

Pathways of Transportation

By J. Monroe Johnson

Assistant Secretary of Commerce

I CONSIDER it an honor and a privilege to participate in this splendidly arranged symposium and am grateful for the opportunity of hearing transportation problems, as related to the various fields, discussed by the able authorities whom I shall presently introduce.

While transportation is as old as he who was made in God's own image thousands of years ago, its major developments have come in the last 125 years. As recently as the close of the Eighteenth Century, world transportation actually did not differ fundamentally from that in the days of the ancients. Indeed, facilities for land travel utilized by George Washington were identical with the mode of King Solomon's day. On the sea the world's best ships were propelled by sails not unlike those used by the Pharaohs. Once the world became transportation-minded, however, as expressed in the demand for speed, comfort, and efficiency, improvements surged rapidly and every major one existing today, except the airplane, was perfected in the period of 1819 to 1901. New and startling advances are now daily occurrences. That is why our pride in the indomitable American spirit of progress and the corollary, genius, is stimulated when we review and contemplate the comparatively brief span of time that separates us from the birch-bark canoe of our aborigines.

Transportation acknowledges a debt of gratitude to the state of Massachusetts, one of the earliest abodes of our civilization. History properly credits this resourceful Commonwealth with much of the courageous and constructive pioneer work. Particularly is there a distinctly maritime tinge in the atmosphere here, hallowed as the destination of the sturdy Pilgrims. Likewise the vision and ingenuity of this state was a springboard from which railroad development acquired momentum, resulting in the modern rail network.

Transportation is the undisputed agency that blazed the pathway of American civilization through primeval forests, and was first projected over Indian trails. From the very beginning, our national development has followed in the wake of well-defined paths, carved by the demand for transportation. Indian traditions record that even before Columbus discovered America, necessity forced transcontinental movements from the Atlantic to the Pacific and from Hudson Bay to the Gulf. Their continuance in the hunter state, attended by frequent wars, compelled incessant movements. Tribal meetings, as well as tastes and search of food made the Indians preëminently a migratory, trail-blazing people. Few white men have equaled them in their instinctive sense of direction, or in their skill to observe the signs by which an obscure but direct and available pathway to the objective may be found. Despite the fruits of modern scientific knowledge, many of our present identical land and water routes, serving as arteries of modern commerce, were traversed for centuries by savage pioneers. Their trails carved out the lines of many of our common roads, highways, and railroads; their light canoes have been supplanted on river and lake routes by our modern steamboats.

While modes, methods, and facilities for transportation are transitory and involve many ponderables and complexities, designated paths are still basic factors in planning transportation on the land, as well as on the sea and in the air. Charted paths have always been the harbingers of progress and civilization, and our advance in their practical utilization has no counterpart in romance, drama, courage, and genius. The analogy between the primitive system and the modern is unique and interesting, and, but for the manner of regulation which we maintain over transportation's extensive path system, we can well imagine the utter maze of confusion and hazards that would impede and well-nigh stifle the movement of modern traffic. Coincident with the charting of new types of paths and the rising tide of transit, new problems of regulation in the interest of public safety are constantly being imposed. With competitive problems thus intensified, a trend toward coördination of all transportation in the interest of economy and efficiency seems not only probable but even unavoidable.

The earliest function of the railroad builders was the carving of suitable paths, an endeavor that engineering genius pursued by conquering natural barriers which earlier trail blazers had considered permanent hazards. The railroads reached their goal in the completion of a vast coast-to-coast network to which the public response resulted in the current density of traffic, requiring regulation; this fortunately has kept pace with development so that the vast and complex system now operates with amazing precision and responds to the modern demand for speed, comfort, and safety.

The development of our great system of highways, that gave impetus to the mass production of the automobile or *vice versa*, introduced additional responsibilities of regulation which were met with a system of traffic signals and various rules in the interest of public safety. Millions of automobiles, one to every five persons, are now utilizing a system of appropriately marked pathways, with such degree of safety as the travelers themselves elect to enjoy.

The ships of the sea have their prescribed pathways and while ocean transportation is almost as old as civilization, science has overcome practically all obstacles and hazards, even to making marked progress in fog penetration. Palatial liners ply the seven seas with their cargoes of human life, faithfully following paths charted for them in the same manner that primeval man and beast followed designated courses unerringly to their destination. A vast system of regulations like-

wise governs the mariner and his crew, and every known device has been invoked to safeguard life and property.

Finally, we have come to travel by air and have perfected aviation to a far greater degree and with far more safety as a practical mode of transportation than has any other nation. True to tradition, the giant airliner must also have its path, which is designated by compass and radio as well as by markings on land. The pilot was first guided by ground lights, but that system did not sufficiently remove the element of hazard, so American inventive genius again responded to a need created by demand for transportation and introduced the radio, enabling the air navigator accurately to visualize his course underneath or over the top, and follow the path day and night.

Notwithstanding the amazing advancement in air navigation, research laboratories are continuously experimenting with additional safeguards. It is a never ending process. Despite the age of transportation, modern improvements did not start until the close of the Eighteenth Century, and virtually every major improvement existing today, with the exception of the airplane, was perfected during the period of 1819 to 1901. As late as 1903, the first airplane was successfully demonstrated when the Wright Brothers negotiated their maiden flight at Kittyhawk Bay, N. C., and now, a third of a century later, scarcely a day passes that some new and startling transportation advance is not recorded. We have come to take our progress as a matter of course, and we cannot now be surprised.

During the recent celebration of National Maritime Day, our maritime history was reviewed from that eventful day in 1819 when the ship *Savannah* completed the first Atlantic voyage made by any vessel under steam. The sailing time from Savannah, Ga., to Liverpool was 27 days. That was an epochal feat and was the forerunner of the development that we have today. Now the Atlantic is spanned by palatial steamships in about four days and by Dr. Eckner's *Hindenburg* in two. Airplanes have cut the traveling time around the world to a little more than a week; some steam and electric trains can exceed 100 miles per hour; while racing automobiles have attained speeds of 100 to 200 miles an hour. The contribution in profit, knowledge, and pleasure which transportation has made to mankind is incalculable. It has turned the world into one great market and its people into one closely knit huge family.

We are now on the threshold of a new advance in ocean transportation, after having virtually lost our maritime prestige to foreign countries. Since the World War we have become woefully outmoded on the seas to the extent that only about 30% of our foreign commerce is carried in American vessels, compared with 90% in the Colonial period when our population was restricted to the Atlantic seaboard.

The coöperation of government with private initiative, particularly with reference to the rehabilitation of the American merchant marine, must continue until obstacles have been removed and our national needs have been met. Problems of equalizing costs for meeting foreign maritime competition must be approached realistically and in the broad national interest, without selfish or political considerations. In this connection, it is pertinent to reiterate that no problems are solved by hysteria or by criticism born of prejudice. Recent verbal *sabotage* has tended to destroy the confidence of the American public in the safety of their own ships. Constructive criticism is greatly to be desired, for from the merging of many viewpoints comes helpful solutions, but no good purpose is served by the dissemination of destructive rumors. As to the safety of American ships, "Lloyd's Register" of England discloses that of ships of over 100-ton capacity of the ten leading maritime countries, the United States and Sweden tied for the lowest percentage of losses incurred during 1934 and reported up to June 14, 1935, although the United States operated six times as much tonnage as Sweden. Eight countries sustained greater casualties than the United States — the British Dominion leading with an approximate loss of one per cent of all its vessels, compared with a loss of only three tenths of one per cent for the United States. Furthermore it is also significant that the records show that the percentage of American seamen operating our ships has risen from 55.8% in 1928 to 80.6% in 1935, or five per cent more than statutory requirements.

I confidently believe informed public opinion favors a renaissance of activity on the shipping lanes of the world, and the coöperation and help of all patriotic citizens of the country will aid materially in reaching the goal toward which we are intently striving.

We must determine now whether we will have an American-built merchant marine manned by American officers and seamen, owned and operated by American citizens, filling the commercial and naval requirements of this great nation, or whether we will surrender the heritage of the sea, handed down by the founders of the Republic. Our present plight is not consistent with our record as the leading industrial and agricultural nation of the world. The history of our national progress is replete with triumphs over greater obstacles than those which confront our merchant marine now. The time has arrived to bring harmony out of conflicts through a procedure of businesslike allocations of Federal aid, properly administered. Such a policy I honestly believe will result in great savings to the American taxpayer and in the advancement of our rank among the commercial powers of the world, so that the American merchant marine may reflect the best traditions of worthy national achievement and assure us against the costly and dangerous plight with which we were confronted at the beginning of the World War.

Crews and officers must discharge maximum duty to the public, a fulfilment of contractual relations, and a patriotic interpretation of their duty as citizens of the United States. There can be no compromise with or deviation from these policies, ideals, and objectives.

Merchant ships must travel the seven seas to deliver our products and in turn bring us coffee and tea for our breakfast, rubber for our automobile tires, dyes for our clothing, and scores of other items which would not otherwise be available to us and the absence of which would transform and complicate our social and economic life. We are not only thus enabled to establish social contacts with our domestic neighbors, but to cross in-

ternational boundaries and cultivate mutual understandings with peoples of other worlds who have different languages, customs, standards, and philosophies. From these new relationships and the attendant understandings, transportation should prove a strong contributing factor to the perpetuation of peace and to permanent social and economic betterment and good will.

It is our history that problems are solved and progress is made under the influence of public demand. Transit advances have come in response to aggressive public sentiment. The public is quick to express its needs for more than it is getting, while, at the same time it usually manifests an unfriendly attitude toward innovations. Back in the days of antiquity, history tells us, chariots and the plainest types of carts and wagons were introduced probably without great public protest, but we do know that when the ancients "went modern" and made the initial move toward comfortable riding vehicles in the form of litters and curricles, the new devices were branded effeminate and men refused to ride in them. Thus for 15 centuries after the fall of Rome, men preferred to travel on horseback. Even in Virginia at one time it was thought unmanly to ride in the carriage. When private coaches were introduced in France and England, there was bitter public protest. Stage coaches were also criticized sharply, but were violently championed when the railroad first emerged. Pioneers in the fields of the steamship, the canal boat, steam and electric locomotive, bicycle, automobile, and airplane encountered public opposition and even ridicule. Naturally, competition was a protesting factor, but other opponents visualized the horrors of possible accidents to such contraptions while carrying human beings. Once the people have accepted a new type of transportation, however, they usually demand a plentiful supply of it.

While it now seems incredible that the public will ever turn from present popular modes of travel, if there is anything in precedent, these may be destined in time to go the way of other forms of transit that were once enormously popular and indispensable. The marvels of today may be the antiquated modes of tomorrow.

We have come a long way from the sailboat days of the Pilgrims, but we have not reached the ultimate stage. The transportation situation calls for wise future planning, based upon careful research and intelligent approach. It calls for a continuing process of legislation in the interest of the welfare of the carriers and the public. We must develop a continuity of policy and of action. Transportation symposiums should be held throughout the country in order that there may be effectuated a coördination of the best thought on the involved problems. But you are here to listen to a discussion of the four fields of transportation by those most eminently qualified thereon and we must proceed to those important opinions.

The Problem of Our Common Carriers by Water

BY EDWARD P. FARLEY

Chairman of the Executive Committee, American-Hawaiian Steamship Company

OUR merchant marine policy from 1917 to the end of the World War resulted in the United States Shipping Board becoming, by 1921, the largest shipowner in the world, possessing a fleet of over 2,000 ships. The control and management of this fleet, and of millions of dollars' worth of shipyards, dry docks, and other property was in the hands of men with little or no experience in shipping.

In 1914 the American Merchant Marine was almost wholly composed of coastwise ships, protected by law from foreign competition. American-flag tonnage carried less than nine per cent of the water-borne foreign commerce of the United States, as compared with 92% a hundred years earlier. The World War marked the opening of a new era, and the tremendous demand for war supplies increased freight rates to the point where shipowning became extremely profitable. By 1915, all American yards were operating at capacity, and the price of ships had started its upward trend.

The withdrawal of foreign tonnage from our commerce created a shortage which seriously interfered with the efforts of American farmers and manufacturers to ship their goods. To cure this, Congress passed the Shipping Act of 1916. This Act created the United States Shipping Board and authorized it to purchase, construct, lease, charter, or operate merchant ships.

On our entry into the War, the Board created the Emergency Fleet Corporation and embarked on the most extensive shipbuilding program ever undertaken, with the result that new yards were built, and contracts for ships placed even in China and Japan. Everything was sacrificed to haste. Economy was lost sight of — over $3,500,000,000 were expended before the program was completed. If the steel tonnage had been built at pre-War prices in American yards, its cost would not have exceeded $650,000,000, whereas the actual cost of these ships was in excess of $2,000,000,000. The difference of $1,350,000,000 can be attributed to war costs.

When the Armistice was signed, relatively few of the ships contracted for by the government had been delivered, and the Shipping Board was suddenly faced with the problem of canceling or carrying out this large construction program, which, by this time, had been so accelerated by the stimulus of war needs as to give it a momentum that was difficult to control. Generally speaking, the policy pursued by the Board was to complete the contracts on which substantial progress had been made and to cancel those on which little or no work had been done. In following this policy, the Board was strongly influenced by the unusual demand for ship tonnage that continued after the cessation of hostilities. In July, 1920 — almost 20 months after the signing of the Armistice — the Board's construction program still called for the completion of 245 ships — nearly half of which had not yet been launched, and in the case of 26 of these, the keels had not even been laid.

At the end of the War, Congress again considered the question of maritime policy and it enacted the Merchant Marine Act of 1920 which makes this declaration of National policy:

> . . . It is necessary for the national defense and for the proper growth of its foreign and domestic commerce that the United States shall have a merchant marine of the best equipped and most suitable types of vessels sufficient to carry the greater portion of its commerce and serve as a naval or military auxiliary in time of war or national emergency, ultimately to be owned and operated privately by citizens of the United States.

To achieve these ends, the Board was authorized and directed to sell its ships to United States citizens "as soon as practicable, consistent with good business methods." In making these sales the Board was required to take into consideration "facts or conditions that would influence a prudent, solvent business man in the sale of similar vessels or property which he is not forced to sell." The Board was also authorized to develop essential trade routes, and to operate its ships on such routes pending their sale or charter to private citizens. The Act further created a construction loan fund to encourage the building of the most modern and efficient types of ships in United States yards.

The collapse of world shipping which so closely followed the enactment of the Merchant Marine Act greatly complicated the problem of disposing of the government war-built merchant fleet. New steel ships, built at a cost of more than $200 a dead-weight ton, were sold by the Board within 18 months after the passage of this Act at $30 a ton. The wooden and concrete ships, which were built as part of the war program, had no economic value, and merely served to decrease the worth of the more useful types. Knowledge that the government would sell its ships served to depreciate the value of private tonnage. The construction of new ships stopped because building costs were out of all proportion to the cost of purchasing Shipping Board tonnage. These conditions greatly retarded the transfer of the government fleet to private ownership and resulted in the disbursement by the government of large sums each year in the operation of American-flag services in foreign trade pending their sale to private interests.

The possibility that such conditions might exist was not recognized in drafting the Merchant Marine Act. This legislation was enacted in a period of high freight rates and inflated values; the operation of American ships under these favorable conditions was profitable and, therefore, it was not considered necessary to provide the means for equalizing the higher operating and construction costs of the American owner with those of his foreign competitor, nor was any effective regulatory protection provided, either in foreign or domestic trade, against the destructive rate competition that was shortly to ensue.

It soon became evident that there could be no new construction for foreign trade by private citizens, nor could existing American ships continue to compete with foreign tonnage, unless the government, by grants from the public treasury, was willing to offset these handicaps and the subsidies paid by foreign governments to their shipowners. Realization of this led to the enactment of the Merchant Marine Act of 1928 (known as the Jones-White Act), which authorized the payment of a subsidy in the form of mail subventions to American lines operating on essential foreign trade routes. In return the contractors had to meet certain requirements regarding the size and speed of the ships and frequency of service. Since the enactment of this legislation, the Shipping Board has sold to American citizens a number of lines in foreign trade which were being operated for government account at a substantial loss. This loss for the 11-year period ending 1933 amounted to $200,208,072. Moreover, 37 modern passenger and freight ships have been built in American yards and are now operating under contracts awarded under the provisions of this Act, and many others, bought from the Board, were reconstructed so as to make them more competitive units. The building of new cargo tonnage for domestic services has been virtually eliminated by the excessive number of government ships that have been for sale at nominal prices. These activities have gone far to reëstablish American shipping in foreign trade.

The responsibility for administering the Jones-White Act was unwisely divided between two distinct branches of the government. Some criticism has been made of contracts awarded under this divided authority and it has been charged that they did not adequately insure against the diversion of the government aid to purposes other than those for which it was granted. The President has recommended to Congress a change from the present system of mail contracts to one of direct government subsidies authorizing the payment of excess cost of constructing and operating American ships. Efforts to reconcile widely divergent views on this subject have badly confused the present situation and rendered the outlook for the future uncertain. Today, for example, we are witnessing the strange spectacle of one government agency recommending legislation to aid in the building of new ships, while another branch requires qualifying speed trials for ships drawing mail pay which, if not unfair, are certainly drastic as compared with the requirements for the same ships when the mail contracts were originally awarded. When acts, such as the Jones-White Act, are passed, it is because of a generally recognized need for adequate government aid, and those

charged with its administration usually apply its provisions in a manner which they believe best suited to accomplish its purpose. Later, when public interest has lessened, there is a tendency to restrict its administration so as to endanger the end which it sought to accomplish. It goes without saying that the government should not condone any contract or arrangement which goes beyond the enabling legislation or which does not properly protect the government's interest. However, it would seem entirely possible that safeguards could have been incorporated in the existing mail contracts which would have prevented the charge that government money was used for any but the purposes intended.

The Shipping Act of 1916 contained provisions requiring that the rates of water carriers in domestic commerce be reasonable and nondiscriminatory and that schedules of maximum rates be filed with the United States Shipping Board. Rate or other agreements between water carriers, restricting competition in either domestic or foreign trade, were made lawful by Section 15 of this Act, provided such agreements were filed with, and approved by, the Shipping Board. The 1916 Act also prohibited unfair competitive practices. Some of these powers were amplified later.

Until the signing of the Armistice, no effort was spared in carrying out the construction program. After that, the cancellation of contracts, the adjustment of construction claims, the building up of trade routes, and the ultimate sale of the ships to private interests, were tasks of sufficient magnitude to absorb all of the Shipping Board's energies, and relatively little attention was paid to the regulatory provisions.

The Merchant Marine Act of 1920 was drafted at a time when the demand for shipping tonnage was greater than the supply, and ocean rates had in many instances risen to fantastic heights. Consequently, the weapons placed in the hands of the Board under this Act were designed primarily to insure reasonable and nondiscriminatory rates to shippers. Furthermore, it failed to give sufficient protection to the shipowner against the destructive competition which, although not then foreseen, so closely followed. This competition was greatly aggravated by the sale and operation of government tonnage.

So far as the domestic trades are concerned, this unrestrained competition manifested itself more particularly in the intercoastal trade — that is, the trade between Atlantic and Pacific coast ports, via the Panama Canal. This was due principally to the fact that the government war-built tonnage was better adapted for use in this relatively long-haul trade than on the shorter coastwise runs.

The history of this trade showed disastrous rate wars following periods of relative stability which were brought about by rate agreements among the lines in which rates were maintained either by the pooling of earnings or the granting of rate differentials. Each period of relative rate stability afforded opportunity for new lines to enter the trade by the purchase of ships from the government at a fraction of their cost and, by cutting rates, to divert traffic from the Conference lines, thus ultimately forcing the disruption of rate agreements to meet this competition.

In 1932 the Shipping Board took cognizance of this situation by proposing to Congress a regulatory act, known as S. 1963, which would have delegated to the Board regulatory authority over water carriers analogous to that exercised over railroads by the Interstate Commerce Commission. Out of this recommendation there finally resulted the enactment of the Intercoastal Shipping Act, 1933. This Act required the filing of the actual rates and practices with the Board. Since its enactment, there have been no rate wars in the intercoastal trade.

The rapid expansion of water and highway transportation since the War, has caused the railroads to request Congress to relax the regulation of their rates in order to enable them to compete on equal terms with unregulated water and highway transportation. Congress, confronted with the necessity of reconciling the conflicting interests of the various forms of transportation to the public welfare, recognized the need for recommendations on this subject from a source removed as far as possible from selfish interest. To this end, it enacted the Emergency Transportation Act of 1933, creating the office of Federal coördinator of transportation, and to this office the President appointed the Hon. Joseph B. Eastman. After an exhaustive study, Mr. Eastman recommended a program of coördinated regulation of competing forms of transportation, centralizing the regulatory authority in a reorganized interstate commerce commission. One of the bills recommended by him provided for the regulation of domestic water carriers, and another for motor carriers. The latter bill (S. 1629) was enacted into law in 1935, and the former is still before Congress. The coördinated regulation of competing forms of transportation in the public interest would seem to be the logical and sound solution to the railroads' demand for equality of opportunity. Nevertheless, the railroads are insisting that the "Long and Short Haul Clause" in the Transportation Act of 1920 be modified in order that they may compete more effectively with water transportation. Such a modification would no doubt result in destructive rate competition between water and rail carriers, with consequent losses to both. Neither the Interstate Commerce Commission, nor the Coördinator, favors such a change.

The necessity for rate stability in foreign trade has not been sufficiently emphasized. Government subsidies alone cannot develop a merchant marine. Frequently, their effect is nullified by subsidies granted by other nations, resulting in an international competition from which no one benefits. The maintenance of fair and stable rates is essential to the development of an adequate merchant fleet and greatly reduces the amount of government aid required to accomplish this. In drafting the 1916 Act, Congress had in mind accomplishing this through Shipping Board approval of conference agreements, as evidenced by the following summary from a Congressional Committee report:

> Practically all steamship representatives who testified before the Committee, as well as a majority of the leading American exporting and importing firms who expressed their views on the subject to the Committee, contended that shipping agreements, conference relations, or oral understandings which steamship lines have effected among themselves in

nearly every branch of our foreign trade are a natural evolution and are necessary if shippers are at all times to enjoy ample tonnage and efficient, frequent, and regular service at reasonable rates. Such agreements, it is contended, are a protection to both shipper and shipowner. To the shipper they insure desired stability of rates and the elimination of secret arrangements with competitors. To the shipowner they tend to secure a dependable return on the investment, thus enabling the lines to provide new facilities for the development of the trade. Furthermore such agreements are held to furnish the means of taking care of the disabilities of the weaker lines, whereas unrestricted competition, based on the survival of the fittest, tends to restrict the development of the lines and in the end must result in monopoly.

In the same Act, deferred rebates were prohibited, thus nullifying the stabilizing effect of conference agreements in a period of surplus tonnage. This has deprived the American shipowner of the principal means used by foreign owners to maintain stable rates and to defend themselves against cutthroat competition in other than American trade routes. Largely because of this, our foreign trade has suffered more severely from rate wars than has the trade between other nations. These violent fluctuations in rates have disrupted our trade and resulted in severe losses to the shipowner. The deferred rebate serves the interest of both shipper and shipowner, and there would appear to be no sound reason why the American owner, alone, should be prevented from dealing effectively with destructive competition.

In 1933, the United States Shipping Board was abolished and its duties and functions were transferred to the newly created United States Shipping Board Bureau of the Department of Commerce. While the Department has exercised its regulatory and other powers in an efficient and forceful manner, nevertheless, it would seem desirable that its quasi-legislative and semijudicial functions be delegated to an independent commission not charged with responsibility for developing our merchant marine.

Probably no form of commercial activity is as involved in its relations with the government as is shipping. A shipowner must comply with the regulations of nine government departments, exercised by more than 25 separate bureaus and divisions, as well as those of 10 independent agencies of the government. Congress, at the present time, is considering a number of bills designed to supplement the regulations already in effect. Some of these are largely the result of a disastrous fire at sea which occurred in 1934. All such bills should receive careful consideration and should be acted upon with calm judgment rather than in a punitive spirit. American shipping men, responsible for large investments in ocean-going tonnage, cannot and do not countenance slipshod or dangerous methods of operation. They would be the last to seek to protect the occasional operator who refuses to maintain proper standards. The very fact that shipping, with its numerous inherent dangers, has been so successful in preventing serious accidents, serves as a strong endorsement of the men who have managed this branch of American transportation.

It is evident that progress has been made in the development of our merchant marine since the War. Nevertheless, it still carries little more than a third of our water-borne foreign commerce. American shipping in foreign trade must depend on government aid and, therefore, the public interest in its continued maintenance, and further development must be demonstrated beyond any doubt if such support is to be given consistently. It is difficult to see how this can be accomplished without a comprehensive survey by a competent and permanent commission, since only by such a study can all the factual data be developed which Congress should properly require in legislating for shipping.

Water transportation, both domestic and foreign, is a facility necessary to industry and agriculture that should be furnished at reasonable cost and without discrimination. The history of American transportation by water demonstrates that no carrier, however efficient, can earn a fair return on his investment until unfair practices have been eliminated and reasonable rates established with some degree of permanency. Experience also shows that voluntary coöperation through conference provides only temporary relief, because the conference may be abandoned or its regulations secretly or openly disregarded. Furthermore, nonconference members are almost certain to enter the trade at the first sign of profitable rates. An admitted chaos calls for a remedy. The effective means of establishing stable conditions in a trade and maintaining fair and reasonable rates on a permanent basis is through government regulation. Such regulation should be placed in the hands of an independent commission. This body should be free from partisan considerations and should have no interest, direct or indirect, in any proceeding which may come before it.

Museum of Science and Industry, Chicago

Highway Transportation

BY EDWIN W. JAMES

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THE subject of highway transportation is about as broad as the face of the earth, as long as history, and as deep as civilization — yet I am allotted half an hour for its discussion! I might spend the entire morning giving you a brief history of road building, or delivering a treatise on the evolution of the wheeled vehicle. I might expatiate on highway transportation as a phase of military strategy. I might philosophize upon highways as an index to civilization or wax prophetic concerning the future of the motor vehicle. I might read you tables of statistics relating to freight and passenger movement by highway or even present a brief on the legal issues involved in the public use of the roads. Actually, I shall touch on a number of these questions, but shall confine myself to American experience and current problems.

Speaking generally, we may say that highway transportation is the first step in going anywhere, and the last step in coming from anywhere. Goods start for market over the highway, and are delivered to the consumer by the same medium. To an increasing extent even the long-distance transportation of persons and property is now by road for the entire trip. This universality of highway transportation puts it in a distinctly different category from any other medium of transport. The roads are common property. Subject only to restrictions in the interests of safety, protection of highway structure, and prevention of exploitation, the highway is free to all.

Highway transportation in this country has passed through two very distinct phases, and is now in a third. These are the prerailroad era, the railroad and canal era, and the automobile era. The first two of these are history, and we can study them with a fair perspective, albeit through a haze of romance. The last is so new, pervades all of our activities in so great a degree, and in its newer manifestations has been developing so rapidly, that it is not easy to evaluate it comprehensively or even justly.

The early history of intercolonial intercourse and of subsequent western expansion is a history of wagon roads. In the course of events the steam railroad made the Conestoga wagon and the Concord coach obsolete, first east of the Mississippi, then, with the resumption of industry after the Civil War, westward to the Pacific. Until the beginning of the present century, the highways were of local interest only: for neighborly intercommunication and for access to railroads, rivers, canals, or seaports. The long-distance intersectional travel was by rail or water. The famous highways of history — the Cumberland Road, the National Pike, the Santa Fe and Oregon Trails, and a host of others — slumbered during the middle period until the motor vehicle started the wheels of commerce rolling over them once again. Fascinating as is the story of transportation during the Eighteenth and Nineteenth Centuries, I must forgo the pleasure of dwelling upon it, for it is Twentieth Century conditions and possibilities that I wish to discuss with you at this time.

The new era in highway transportation, destined in the light of history to be as far-reaching and romantic as any in the past, is the era of the motor vehicle. It has been made possible by the invention of the internal-combustion engine and the pneumatic tire; which of these has been more important would be a fair subject for debate. One need not be old to be able to review in his own adult lifetime the entire practical development of the automobile and "good roads." The bicycle first created the demand for improved road surfaces in the "Gay 'Nineties." The automobile found these roads to its liking and intensified the demand, but — much more important — the automobile soon proved that it actually could go places. Its radius of operation extended beyond its own immediate neighborhood. Good roads were not enough if they went only in disconnected scraps to or by the property of whoever had most influence with the road authorities. To secure the full benefit of the motor car we had to find a way to connect these many bits of new road into continuous routes. The Federal Aid Act of 1921 recognized this need. Federal aid to the states for highway construction had been initiated in 1916, but in 1921 it was definitely provided that Federal aid funds could be expended only on a limited system of highways, to be mapped out in advance and approved by the Federal government. This system was limited to a maximum of seven per cent of the total public rural-road mileage in any state, a percentage which it was estimated would provide for the interconnection of all important cities and county seats with at least one north-and-south, and one east-and-west road in each state.

We now have the improved system of highways that we set as our goal 15 years ago. Practically speaking, we can now go anywhere in this country by automobile, at any time. Our only difficulty, if any, may be met in traveling the last few miles to our destination over unimproved local roads. We have the greatest system of highways the world has ever known, yet I am confident that we are only at the beginning of our new era of highway transportation. The highways have made for themselves an important place among the agencies of travel and transport — not wholly without challenge, but unquestionably secure. Whether at the moment we can define this place in satisfactory terms is not particularly important. The fact that such a place exists is evidenced by the facts that we have built a large, correlated mileage of highways in response to a universal demand and that these highways are being used daily by millions of vehicles in the carriage of passengers and freight.

Highway transportation, with all its subsidiaries, is our biggest industry today. We have in this country about 3,000,000 miles of rural highway, of which nearly ten per cent is improved with some sort of surfacing to make year-round travel possible. Of 324,312 miles of primary state highways at the close of 1934, there were 109,691 miles improved with "high type" surfaces. Forty-six per cent of the Federal Aid System is now surfaced with high-type pavement, and only ten per cent remains unsurfaced. Expenditures during 1934 for state highway construction, maintenance, and administration (exclusive of interest and amortization payments) totaled $909,659,000 — nearly a billion dollars.

Using these highways are 26,000,000 motor vehicles, including more than 3,500,000 motor trucks. The wholesale value of new motor vehicles, parts, and tires in 1934 was $2,500,000,000. It has been estimated that in recent years 5,000,000 or 12% of those gainfully employed in the United States, have been employed in the manufacture of motor vehicles and supplies, the construction of state and Federal highways, and the driving of trucks and busses. All of this has grown from a truly infant industry in the course of 30 years.

Where do we go from here? Certainly we cannot and will not stay where we are, if for no other reasons than that our highways are annually taking a toll of 36,000 lives in traffic accidents or that highway competition with other agencies of transportation has become a national issue. We are paying an incalculable price for the inadequacy of our highway management and operation. These are still as far behind the potentialities of the motor vehicle, both in relative efficiency and completeness, as they were 25 years ago.

Let us consider some of the major responsibilities that confront us: Our main roads are passable but by no means adequate, either for safety or for freedom of efficient use; our local roads are hardly out of the horse-and-buggy stage of development; the economics of highway taxation and finance are still a virgin field of study; finally, the regulation of highway transportation as a public utility faces us as a major administrative problem.

Our main roads are passable, but on how many of them can a modern motor vehicle be used safely to anything like the extent of its capabilities? So rapid has been the development of road transport that much expensive highway construction has become obsolete almost as soon as it has been completed. This inadequacy of our main highways manifests itself in two ways: an appalling toll of accidents and a less spectacular but seriously wasteful restraint on vehicular movement due to congestion or conflicting demands.

The most immediate problem of highway transportation at this moment is the safe use of the roads. Expressed in terms of 36,000 deaths annually, serious injuries to perhaps a million men, women, and children, and a property damage that we cannot even estimate, it challenges our best efforts. Accidents happen sometimes because of defective or neglected mechanism in the vehicle, sometimes because of poorly designed highway or improper roadway surface, and sometimes because the vehicle operator is reckless, careless, or lacking the physical or mental ability to handle a powerful vehicle safely. Usually several of these factors combine; the typical accident happens when a less-than-perfect driver finds himself in a more than ordinarily hazardous situation.

The reasons why our progress toward highway safety has been so slow are several: First, the multiplicity of accident causes is so great that we cannot yet with confidence say what is safe and what is dangerous in highway design and traffic regulation; second, despite convincing evidence as to the safety of certain expedients, we are forced somewhere to compromise with cost, and must depend on the motor-vehicle operator to make reasonable allowance for the shortcomings of the highway; third, the major responsibility for safety must in the last analysis rest on the highway user, that is to say, on each of a hundred-million persons, more or less. Nevertheless, we can and must find ways and means to achieve the safety that our railroads and many industrial plants have achieved by unremitting effort. Traffic accident statistics are reasonably complete and accurate in very few of our states. In only 12 states is it required that accidents be reported to some centralized state authority. Few states have made any attempt to analyze in detail the combinations of circumstances under which accidents occur, or to refer the individual accidents to the particular spots at which they occur, with a view to applying local remedies. Numerous cities are doing excellent work, both in accident recording and analysis, and in the development of safety programs.

Outside of correcting conditions at points where accidents have been frequent, our practical problem is not so much to discover what will make an absolutely safe road, as to balance degrees of safety against the highway budget. We know, for example, that divided roadways and separated grades at intersections reduce our accident risks, yet such expedients are too costly to warrant their use at present on any but our major highways. We know that modern highway lighting systems will prevent many serious night accidents as soon as we can find the funds for their installation.

On our lesser roads we must do the best we can with less complete protection: liberal lane widths, well-designed shoulders, painted center lines at hazardous points, and warning signs. Regulatory measures must compensate for deficiencies in physical safeguards, and the highway user must accept the responsibility for driving with reasonable care.

Closely akin to accident hazard on the highway is the delay due to inadequate highway facilities. We cannot expect to travel at all times at speeds equal to those possible on the most modern rural highways, but we can hope to remove some of the obstacles to free flow which now exist. Much of our present delay must be incurred in the interest of safety, hence up to a certain point the same highway improvements will serve both of the ends sought: safety and the saving of time. Wider highways, for example, permit each vehicle to keep to its own most efficient or preferred pace, passing slower vehicles freely and without hazard — a consideration of particular importance in hilly country. Various types of parkways, elevated highways, or other "freeways" provide facilities for travel unhindered by the congestion and hazard that cannot be avoided where access to abutting prop-

erty is permitted or where intersections at grade occur in their usual abundance. Intersection designs, especially for major traffic routes, have been developed to eliminate all need for one vehicle to cross the path of another.

The second major problem that demands immediate attention is the improvement of our 2,500,000 miles of local roads. Some of these might well be incorporated in the major highway system. Most of them, however, are to be regarded as "land service" roads, individually of purely local interest, collectively of fundamental concern to all of us. Now that we have our network of improved main roads we must see to it that our rural population has year-round access to those main roads. Recent legislation has made Federal funds available for the improvement of local roads. As an initial step toward the more effective use of these and other road funds, the United States Bureau of Public Roads is coöperating with the highway department of nearly every state in making, for the first time, an inventory of all highways, with a study of the traffic on each. When we have this detailed information assembled we shall be able to classify our highways on the basis of their importance, and establish a program of progressive improvement.

The economics of highway construction and maintenance I have mentioned as the third of our major problems. Highways cost money — about a billion dollars a year exclusive of city streets. In earlier times men worked on the road with their neighbors, or paid toll for traveling improved turnpikes. We see some survival of both these institutions still, but for the most part the technicalities of road construction and the advantages of modern road machinery have made it impractical for the farmer to work out his road tax and, except for numerous toll bridges (many of them publicly owned), all roads are equally free. The only source of highway revenue, other than tolls, is taxation. To be fair to all, and to develop all sources of taxation most effectively, we must learn a great deal more about where our highway dollar comes from and how it is spent. The incidence of taxation, particularly of the special highway users' taxes, must be compared with the allocation of the benefits of those taxes. The property tax, though still the mainstay for local road construction and maintenance, has practically disappeared as a source of revenue for state highways. The through routes, used principally by traffic that in no way concerns or benefits the local property holder, are financed by gasoline and motor-vehicle taxes and by general taxation. The problem goes deeper than this, however. Are the various classes of highway users paying special highway taxes in proportion to the benefits received by them? Do, or should, heavier vehicles pay directly in proportion to the extra cost of providing them with heavier and wider road surfaces? Do the city dwellers pay more than their share of the gasoline tax allocated to rural highway construction and maintenance? One of our most serious concerns just now is the growing tendency to divert the proceeds of the gasoline tax, originally intended for highway purposes alone, to other ends.

The United States Bureau of Public Roads in coöperation with a number of the states is making a detailed study of this taxation problem. In addition to a careful analysis of state financial records, data are being gathered from representative samples of motor-vehicle owners, to measure road usage by the different groups.

Finally, I come to consider the question that is uppermost in the minds of most of us: the problem of regulating highway transportation as a public utility. The practical problem is so to develop this means of transport that it will be of the greatest possible advantage to the country as a whole. I have already remarked that the mere fact of the existence and current growth of highway transportation establishes its clear case for "public convenience and necessity." Like any public utility, however, regulation is necessary for the public interest.

The conflict of interest and opinion as to highway transportation lies in the fact that there exist also other means of transport between points on land that are definitely competitive with the highways: coastwise marine shipping, river and canal transportation, the railroads, and, most recent, the airplane. All of these represent large investments and a wide distribution of security holdings. Any change that threatens partly or wholly to supplant any of these necessarily demands the most careful study.

Each of the several methods has its advantages and its limitations. These advantages and limitations are the fundamental bases for any division of the transportation field. They are not absolute: They vary with a multitude of geographical and physical circumstances. Nor are they mutually exclusive: In many fields there is a wide choice of transport available. A given journey may be made by road, rail, air, or even water, the deciding factors often being largely psychological on the part of the traveler. All four kinds of transportation can and do exist side by side between competitive points. Similar alternatives are offered for the movement of freight, the choice between them depending more definitely on economic considerations. We cannot solve the competitive situation by definition, nor can we do it overnight by heavy thinking.

I think we can agree that some degree of regulation of highway transport is necessary if competition with other transportation is to be kept within economic bounds. This is particularly true of commercial transport. There has been general agreement that the private passenger car shall move freely and unrestricted, regardless of state lines and subject only to ordinary registration requirements and traffic regulations. The motor truck, on the other hand, has generally been classed as a commercial vehicle and often subjected to special regulation and taxes, particularly in interstate traffic. Vehicles carrying passengers or freight for a consideration, and so using the highways as a place of business, are everywhere put under some sort of permit or franchise restrictions.

Surveying the whole field of highway transportation with reference to future possibilities, there are three major efforts that must be made to secure full accomplishment. The highways must be made safer and operation must be sufficiently controlled to assure safer use. This effort will be directed toward a study of present conditions of alignment and correction of hazards of all kinds along the present improved roads. It will cover the whole field of driver qualifications, traffic rules and

regulations, and motor vehicle licensing and registration. Work is already being done in both lines of endeavor by the Bureau of Public Roads, the states, and other interested agencies.

The second major effort necessary to develop full possibilities of motor transport is to determine its economic place in the entire transport regimen of the country. Obviously, highway and rail transport impinge upon each other more directly than highway and any other form of transportation, and fixing the most advantageous and economical relationship of these two is the purpose in view. The matter is not simple of solution, as I have already implied; it has serious pitfalls in the way of general losses to investors, capital requirements of the railroads, existing law and established and often too inflexible practice. It seems clear, however, that there are elements of the problem that may at once be largely or entirely removed. There is first that large phase of highway transport, both of passengers and goods, that in no way has competed, and will not compete with the rails. This is the service to small population centers and settled rural areas which the railroads have never reached. This field, properly served by the highways, may become a heavy contributor to railroad traffic. At the other end of the scale is a certain class of traffic which belongs naturally and economically to the rails and probably will not change. This class of transportation covers all long-distance movement of bulk commodities. Between these two elements lies a third, debatable, competitive, and still awaiting adjustment. The future of highway transportation requires determination of economic and practicable relations with the railroads under competitive conditions. It would be a daring man who at the present stage would venture to outline a definitive plan in this field. It will be one, in all probability, of long and gradual development.

Finally, there is an effort needed, which is now under active promotion, to carry to its logical state the service to small population centers, and to settled rural areas, which constitutes unquestionably the legitimate field of highway transport. This effort will be directed toward the extension of improved highways into the regions not now adequately served. How far this extension is to go depends in the immediate future on present available funds; it will be a continuing process, planned to meet the growing and changing requirements of rural development. The details affecting the expansion are numerous and varied. They will not remain what they are today, for there will be increasing and decreasing justification in different areas. The work will affect not only the roads of secondary importance, but as these are increased in number the main roads will have to be enlarged in capacity to accommodate the greater traffic. As this process continues, our country as a whole will become more and more inviting for rural habitation, the way will exist for a more uniform distribution of rural population, and the work will not be finished until our population has become stabilized — a point in the future which no one can forecast.

The Railway Outlook

BY CHARLES D. YOUNG

Vice-President, the Pennsylvania Railroad Company

WE are living in a dynamic era. Social and economic conditions are rapidly changing. Rapid transportation and mechanical communication are so universally part of our daily life that the present generation talks with more people and hears and sees more of the world and its events than was possible in the combined scope of two or three generations before the present era.

One effect of this change is the tendency of our people to become segregated into more sharply defined economic groups determined largely by their vocations, and as these groups grow they become more distinct but more dependent upon each other. Transportation and communication are the facilities which serve this interdependence.

Water and rail are old types of transportation; motor highways and airways are relatively new. The messenger and the mail preceded the telegraph, but now by means of the telephone and the radio more is accomplished in one day than was accomplished in a year a few generations ago.

What is the future of the railways in this situation? Are they to be superseded? The answer is, emphatically: No. Are they to be correlated with other forms of transportation? Yes, and a forecast of the immediate future shows very clearly that the change is in the direction of progress as regards every field of transportation service.

What is the motive power of the future? Steam? Yes, probably propelling direct and by turbogenerator. Why? Because of its further possibilities of economy and efficiency. Diesel-electric? Yes, for certain classes of trains, and for switching purposes where steam, for reasons other than for propulsion, is not desirable. Electrification? Yes, in dense traffic territory, both underground and on the surface and for all classes of service. Will the passenger car change? Yes, largely in the direction of comfort to the passenger and of increased esthetic appeal. The trend of freight car design will be toward specialization in service and greater average capacity. Freight trains will be longer, will move faster, with fewer intermediate stops at freight yards, thus eliminating time loss and expense, as railways are consolidated.

The remaining yards will be more extensively mechanical in their operation than in the past, with less shock to lading and equipment.

Speed of trains will increase — competition will see to that. The extent to which speed has already been increased in recent years is seldom realized. Lightweight materials will be utilized as their use is justified by the cost. The riding qualities of the track will be improved, principally at turnouts and by changes in or elimination of rail joints. There will be fewer but larger local stations and coördination with highway vehicles serving the intervening territory. Signaling will be improved by the extension of the cab signal system and reduction in wayside indications. More train dispatching will be done by centralized control of signals, thus replacing the dispatcher's telegraph key and telephone. Freight containers, truck bodies, truck trailers, and trucks loaded with their commodities will be moved in freight trains for distances beyond the economical limit on the highways. Collection and delivery of freight will be universal — that will come for passengers, too.

We see many improvements ahead resulting in better service, ultimately at lower cost, and that means, of course, money must be spent for these betterments. While these improvements to expedite the movement of traffic and eventually lower the cost of transportation will change the kinds of labor employed, the greater volume of traffic attracted will increase rather than diminish the total railway employment.

How do I know all this? I don't. It is a judicious estimate from the trends of the times; it is more accurate than a guess. For the fact is that the whole railway outlook today so far as management is concerned is one of progressive betterment of service and equipment.

My assignment from your distinguished chairman, however, as I view it, does not stop with this forecast summary which is only part of the picture of railway development. It is desirable that we know how it contributes to the welfare of the public.

The usefulness of a man to society is measured by his achievements. The usefulness of an industry is measured by the quality of its product, the place that product occupies in our daily life, and the contribution it makes in lifting the standards of living. The usefulness of the railway is measured in all of these ways. Its policies are determined by men of vision and force. It serves the public in times of stress, through prosperity and adversity. Many features of service can be rendered satisfactorily only by the railway. It has a greater variety of contacts than any other industry. It serves the humblest passenger, the farmer, the worker in forest and mines, the industrialist, the banker, the Federal and state governments. An industry which received nearly three-and-one-half billion dollars in 1935 from the public for services, and paid almost two billion dollars in wages, over one-half billion dollars for materials and supplies, and one-quarter billion dollars in taxes must occupy a vital place in the lives of the people and it deserves a substantial portion of their thoughtful consideration. The record is one of progressive accomplishment.

Since railways have grown with the country and enabled the country itself to grow during the past 100 years, the physical development of the two have followed parallel lines. The railways were the trade routes. Industrial expansion has followed trade routes: Mines were opened when they could be reached by railways; cities expanded when served by railways; manufacturing plants were placed at suitable points between sources of supply of raw materials and the markets for their finished products, because of the knowledge that the railways would adequately serve both requirements. To perform their service, industry and railways built up enormous capital structures, each depending upon the other for sufficient earnings to justify the investment. Those interests therefore became so firmly interlocked that any fundamental change in the economic system generally could not fail to affect the railway and its security holders, specifically.

We are too close now to the changes that are occurring, and the observation of their effects has been too limited by time to enable us to draw accurate conclusions as to their real nature and ultimate results. However, there are certain trends which may be useful in our efforts to anticipate future conditions which the railway must meet: (1) The inclination of the public to avoid advance purchase commitments. When the decision to buy is reached, shipments are wanted at once. (2) The desire of the public for increased speed and comfort in passenger travel and the obvious need for greater flexibility and speed in freight service. (3) Movements toward the regulation and coördination of all forms of transportation and other public utilities; the competitive urge, however, is essential for progress and must not be disregarded. (4) A definite movement toward the consolidation of facilities and services of railways with railways, and of railways with truck and bus operations. (5) The modernization of plant and equipment. (6) Public demand for a reduction in total transportation costs, regardless of the kind of transportation used. (7) The revision of the financial structures of railways for the purpose of reducing fixed charges and obligations no longer self-supporting. (8) The substitution of cheaper or more appropriate forms of transportation on branch lines where existing service is not profitable.

What is the railway doing to meet the objectives of those trends? In the first place we should know something about the financial resources of the railway. On the capitalization side we have in the past by legislation, regulation, and public demand for safety, and to avoid delays and congestion, forced them to expend capital for facilities and equipment. This maximum investment made with the approval of the regulatory authorities must be sustained and if not utilized by the public it is a loss to the security owners. With this necessary investment we must inquire in good and bad times what the railway must do in meeting expenses, taxes, and fixed charges, and then how much is left for dividends, profit, or betterments. Obviously, unless a profit on an operation is realized or is in prospect, there is little hope of attracting capital for improvements. It is imperative for their growth that the railways maintain their credit.

The operating ratio — which is the measure of operating efficiency — for all Class I railways of the United States in 1935 was 75.11, in the face of increased costs of labor and materials. The railways prospered during many years in the past with a higher ratio, but the gross

earnings were greater. This shows that management has been able to control operating expenses, yet, because of reduced gross earnings and higher overhead costs imposed by legislation, taxation, and regulation, the remaining margin that should exist to maintain net income—the final result upon which railway credit rests—has been growing less. A revision of the financial structures of many railways is one of the predictions that can be made with reasonable assurance, unless there is a substantial and continued improvement in their traffic. The more expeditiously this transitional phase of the railway credit position is corrected, the better for the industry.

Only three general methods of improving the situation financially seem to exist: 1. *Make further reductions in operating expenses.* Careful studies show that, while smaller economies are currently made, the big opportunities are isolated, will require time for accomplishment, and are inevitably accompanied by adverse effects upon the values of adjacent property, upon the earnings of labor, and upon the earnings of those affected by the reduced buying power of labor. There is abundant evidence of the fact that, within the limits of its power and consistent with its responsibilities to the employes, management has already been aggressive in effecting operating economies, and meeting the requirements of its employes.

2. *Reduce fixed charges and taxes.* This is now being accomplished chiefly where receiverships and reorganizations are in progress, the primary purpose of which is the forced reduction of fixed charges to a figure which seems justified by earnings. This forces the distribution of losses uniformly among security holders, possibly taking away from securities a financial return which has been regular and fairly certain and substituting a speculative return based on possible future earnings.

3. *Increase gross earnings.* It is this method that offers the challenge that railway management welcomes and accepts — a challenge which compels the adoption of the most ingenious devices and methods that science and engineering in the hands of management can produce to give the public a useful and attractive service. Then the results of the working of the natural law of the survival of the fittest will become evident in transportation. The public is usually quick to respond to service well rendered, and ready to pay a fair price for it.

It would be folly to attempt to predict the details of the popular form of transportation of the future, or to plan definitely, far in advance, radical changes which might violate the principles of sound railway operation, but it is possible to show briefly the ways in which the railway is endeavoring to anticipate certain changes in the transportation needs of industry and the desires of the public at large.

An evident change in mental attitude during the past decade is that brought about by the more rapid exchange of communications and the expansion of industry. The consumer wants no idle capital tied up by delayed transportation and no divided responsibility from the time the order is placed until delivery is made at his door. He wants to mail or telephone his order and receive his goods with as few intermediate processes and as expeditiously as possible. The order may involve a 100-pound shipment or a 100,000-pound shipment; a successful transportation system should be prepared to meet that demand. Experiment has developed the railway container service, the rail-truck pickup-and-delivery service, and the road rail car to meet the demand in a practical way, and yet that need has been met only partially. Further coördinated research work is required, including marketing and distributing methods generally and an appropriate tariff for the service. It is a reasonably safe prediction that whatever outstanding accomplishments are developed in transportation to meet a future public need, will be developed through a coördinated research group including railways, manufacturers, universities, institutions, and governmental departments equipped to make appropriate studies.

One of the anomalies of today is that so little realization seems to exist as to the extent of present railway research. Literally thousands of men are engaged in the kinds of research on railway problems, which if they were undertaken by younger industries would be widely acclaimed, but since they relate to studies for reduced operating costs and for continued safety, rather than for styling and selling value, little is heard of them. The fact is that research has become an established, continuing factor in the railway industry — so productive, indeed, that its results today are remarkable, yet are accepted as commonplace.

The desire of the public for speed and comfort is definite and unmistakable. Increased speed on the railway, however, is not simply a question of developing motive power that will run faster. It means improving the track structure, reducing curvatures, revamping signal systems, protecting or eliminating highway crossings, and many other changes. Because of the expenditure necessary and the time required to prepare for it, substantial increases in sustained speeds for regularly scheduled trains will come gradually. There is reason to believe that the increased comfort of the passengers will receive in the future as much attention from the designers of railway equipment as it now receives from the designers of automobiles. Changes in that direction not only may be expected — they are on the way.

As suggested by Dr. Harold G. Moulton and associates in that very comprehensive book entitled "The American Transportation Problem," industry will tend to decentralize outside the densely built up sections of metropolitan centers to secure better labor conditions, lower taxes, and other advantages. It is, therefore, conceivable that freight terminals serving congested areas will be so relocated and the truck used to transport the lighter freight from the shipper to the terminal and from the train to the consignee.

Experience continues to be our best teacher. We may build up attractive theories about the way we should travel, the standard of living we should enjoy, and the way our freight should move, but in the final analysis methods are used which experience demonstrates are most satisfactory for society generally, and for which the public must be willing to pay. It is still a case of trial and error or trial and success.

A testing of the fitness of the various forms of transportation is now proceeding right here in New England where much pioneering has been done for the past 300

years. It is particularly fitting that New England should be a territory in which the relative merits of the various forms are being determined, and it is because we are today gathered here in Cambridge that I am using the situation in New England as a text for this part of my remarks. The experience gained here will be useful in fixing transportation policies for the country to meet the needs of the future.

With regard to water-borne transportation: The ports of New England have furnished facilities for its development, for determining its cost, and for demonstrating its practical value. As evidence of the trend of water-borne traffic through the ports of New England, it is interesting to note that ten of its largest ports showed an increase of 30% in tonnage during the decade ending in 1934 — a period when the value of the output of industries of New England decreased 52%.

With regard to highways: Geographically, New England covers the extremes from a densely populated zone, some 75 miles wide along the coast, to the sparsely populated areas of northern Maine, which fact permits a test of highway transportation under widely varying conditions. In this zone of greatest population are highways joining cities and towns where the motor truck, motor bus, and private automobile are the most popular instrumentalities for local transportation of passengers and freight — where the hauls are short and the service frequent.

Railway branch lines, constructed before the internal-combustion engine became practical in transportation and permanent highways were constructed, are now being abandoned in that territory, not, however, because they were an economic waste. They served a definite purpose in the development of the territory and their construction was justified. They illustrate, however, the hazards that fixed capital is constantly incurring of meeting competition from a previously undeveloped scientific discovery which the ingenuity of the engineer later makes useful to society.

New England, for example, is a territory in which the manufacturing industry has been developing through many years — over a longer period perhaps than in any other section of the United States. With that industry have been developed groups of workers skilled in tool making, textile dyeing and finishing, boot and shoe manufacture, silverware, and many other lines of work, who have their homes in New England and want to remain there. Yet because of the growth of population westwardly and the growing competition of similar industries in other territories, it is more and more difficult to keep industries in New England operating on a profitable basis.

New England cannot consume all that her factories produce; she must reach markets outside her boundaries. Therefore, it is imperative that access be had to transportation facilities which are suitable for long hauls, preferably by competitive routes. The alternative is a decline in New England industrial prosperity and the loss of the trained personnel which has grown with the industries. The same need exists for transportation facilities for bringing the raw materials and supplies from their sources to the industries. It has been estimated by Professor William J. Cunningham of Harvard University, in his chapter on "New England's Prospects — 1933," that for every three carloads of manufactured products moving west from New England, five carloads of raw materials move east into New England.

Due to the competitive urge, the railways of New England built up passenger and freight terminal facilities in order to attract business to their respective lines. The cost of terminal operation is one of the largest elements of expense to railways and that cost must be absorbed in the road haul. If a railway has a short road haul and an expensive terminal in which the business originates and another expensive terminal in which it is delivered, it is perfectly clear that such a railway is handicapped against one with a long road haul between terminals. Where such conditions exist it is essential that those railways be consolidated or affiliated with railways having long hauls over which their terminal costs may be distributed. Where this relationship does not exist and they make a rate which is high enough to cover their road and terminal costs, that rate is so high that the traffic is lost by the railways to cheaper forms of transportation.

The type of transportation planned for the future requires not only a consideration of the survival of present transportation systems and of the diversified institutions whose investments therein are at stake; it involves also the future economic welfare of these New England states, whose population must be served in such ways as to prevent economic disturbance and to keep the highly skilled worker in his home environment. New England conditions are typical of those in most of the middle-eastern coastal states, which are already feeling the effects of the growth of population westwardly and the competition of industries more favorably situated in regard to sources of much of the needed raw materials, markets, labor, and the social conditions under which labor may be employed.

It occurs to me to suggest that the London Passenger Transport Act of 1933 may be a directional sign for a portion or for all of New England in rationalizing the present conflicting modes of transportation and the regulatory bodies in the several New England states. Under this Act the London Passenger Transport Board has given an outstanding example of progressive action in making use of the advantages of various forms of transportation by coördination in a densely populated area. The plan adopted has to do with the urban and suburban handling of passenger transportation in London, and while all of the details might not fit American methods, it is cited as an example of coöperative action in a highly complex transportation situation taken in the face of great difficulties. The principle might very well be studied as to its applicability to New England and its environs from a freight and passenger point of view.

A comprehensive study of the American railway situation was made by the Coolidge Committee, composed of eminent Americans, appointed to recommend a "solution of the railroad problem, as an integral but the most urgent part of the entire transportation problem." Their report made in 1933 said, among other things: "The railroad system must be preserved. It is the most important single element in our social and economic

life. . . . Unprofitable railroad services should be replaced by cheaper alternative transport methods." That is what an able national committee said. That committee obviously had in mind the thought that present conflicting modes of transportation should be coördinated and each made to render the service for which it is best fitted.

New England cannot disregard its sources of raw materials nor its markets for its finished products. Therefore, the transportation system which unifies its own interior problems and at the same time provides for transportation connections with the balance of the country must be recognized as of paramount importance for New England's prosperity. Such connections known to New England as existing rail traffic gateways should be continued, the volume moving through each to be determined by the service of the route. The difficulty is to maintain those gateways in conjunction with a unified New England transportation system without slowing up the movement in making the interchange between railways.

Concentration of traffic through certain of the gateways is helpful in eliminating loss of time in effecting interchange. With the decreasing of the time element, by eliminating yarding, New England would be served by a continuous flow of well-expedited traffic. It is highly desirable that more of those through routes be under either unified supervision or management in order to avoid divided responsibility, which is a handicap to expeditious movement.

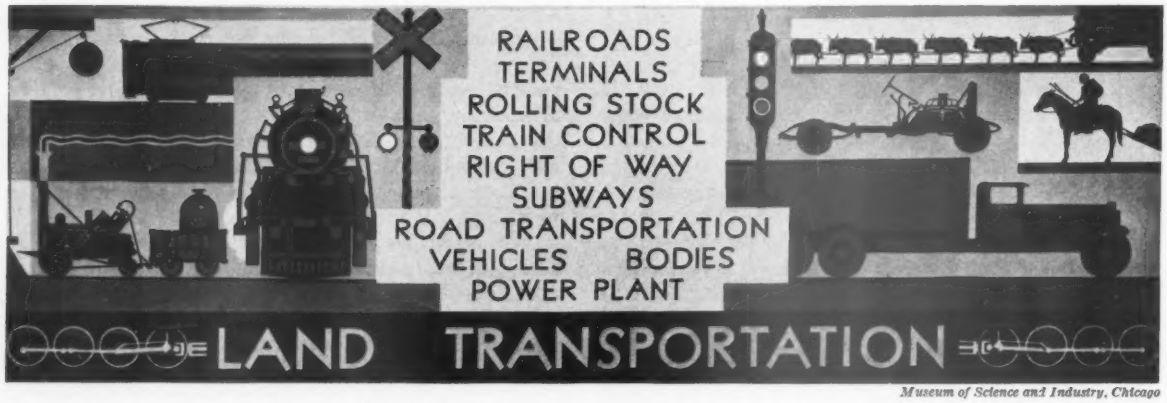
The railways are and will continue to be the backbone of the transportation body of our country. Ships, trucks, busses, private automobiles, and airplanes have their places. The effort of railway management now is to determine the place the railway best fits in the transportation body, then to concentrate on making that part function in the best possible manner. This will require not only the joint efforts of the scientist, the engineer, and the economist to find the possibilities, and managerial ability of a high order to convert those possibilities into useful functions in the public interest, but also a like attitude on the part of competitive transportation so that the two may be coördinated and give the best service at the lowest possible cost. The railway industry has those talents today and is at work on these questions.

It must be borne in mind that the public is always impressed by the new and the spectacular. Old methods and devices, even when they continue to serve us well and to advance with us, are taken as a matter of course and seem colorless. The passenger automobile, the bus, truck, and airplane are new and still in the developing stage. There is novelty in their design and romance in their operation. They have an irresistible public appeal during their growing period. Like the Easter bonnet, they have yearly models. The railway, notwithstanding its consistent progress, is a commonplace facility in comparison and its advantages as a transportation agency are not surrounded by the color of the younger competing forms.

The railway is rendering a valuable public service that must be continued. No substitute has yet been developed that will as a whole perform the same service in any better way. The future points to a coördinated system of land, water, and air transport which the railways are in a position to accomplish because they are the backbone of the transportation structure. They should be relieved of existing restrictions preventing ownership within the rail industry as well as in other forms of transportation. They should also be relieved of the existing hit-or-miss plan of governmental regulation and control without corresponding responsibility for the results, financial or operating, or the effect upon relations with labor, or labor itself.

The railways face the future with confidence and if governmental regulation and direction will follow principles of a broad and sound policy, the changing public demands and economic conditions can be met by the rails through the ingenuity of the experienced engineer and the skill of expert management. Thus, the coördinated transportation of the future will equal or excel that ever produced by the railways.

The railways are a necessary unit in a coördinated system of transport and until something else comes along to take their place, they will be the backbone of the transportation structure in any and all sections of our country.



Museum of Science and Industry, Chicago

Current Trends in Air Transportation

BY EDGAR S. GORRELL

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THIS subject embraces the whole range of human, economic, and scientific relationships. Miss Dorothy Parker in reviewing the dramatic efforts of a certain movie star wrote: "She covered the whole gamut of human emotions from A to B." That is approximately as far as anyone may hope to proceed in this complicated subject within the time allotted to me.

Beyond question, the air transport industry comprises three main aspects — one to an extent greater than most other industries: economic, political, and technical. This is not the order of their importance; in this industry, unfortunately the relative importance of one to the other varies from time to time. Always we wish we could forget about the political aspect, but perhaps it is well for us that we have had this, for in some ways it has accelerated development. Sometimes the very extreme hardships placed upon the industry by political expediency have hastened rather than retarded economic and technical development. There is not much question that the limitations placed upon Germany by the Treaty of Versailles accelerated the development of technically and somewhat economically sound commercial aircraft in that country. The German aviation industry immediately after the War had a definite set of rules to follow and laid out its designs and production in accordance therewith. I believe we need a rule book and reasonable assurance that it will not be changed drastically without notice. The transports in current use, for example, were designed to make money under a set of rules which do not apply today. This is one reason why we have had to seek means of financing new equipment.

I shall take up the subject of economics first — current trends in the economics of air transportation. At the present time approximately 30% of the revenue of United States' air lines come from mail; the 70% remaining comes from passengers and express. It has been said that in Europe 80% of the total operating revenue of air lines comes from the government. Our service is better, faster, more comfortable, and safer. Passenger-mile statistics indicate that the European air lines are but one tenth as safe as all our air lines in the aggregate. In spite of our enviable operating record, the air lines of the United States lost $4,000,000 during the last fiscal year; for the calendar year 1935 this was reduced about one half. Considering revenue received by the government from the sale of air-mail postage, the so-called subsidy to the domestic air lines during the last fiscal year was under $3,000,000. Certain air lines received less air-mail pay than the government received for the postage sold and used over their lines. In other words, these mail carriers are subsidizing others that do not carry the large loads. It is logical and fair that the smaller air lines have contracts, and this is something which we hope will be straightened out without disadvantage to the public and the industry. But it is a knotty political-economic problem.

Many of my fellow Alumni of M.I.T., thinking of the romance and the future of this industry, probably envy men who are in it. Do not jump to conclusions about this. We have a maximum limitation on the compensation any individual connected with a company in our industry can receive, the like of which is contained in the laws of no other land nor does it apply to any other industry in this country. On the other hand, there is a minimum salary which our industry may pay to certain of its high salaried personnel — the pilots. As a consequence, some of the most intelligent men in our industry remain as pilots. The president of one air line flies a regular run and is paid over $700 a month as a pilot by a company that cannot afford to pay him what he is worth as an executive. The maximum compensation feature of our legislation limits any officer, director, or employee to compensation from any air-line company source in excess of $17,500 a year. The law makes it a crime for any individual employed regularly in this business to exceed this figure as his compensation from any company. If we want to hire a business expert or a Kettering to solve certain serious and difficult business or technical problems — and we have them — we cannot do so unless patriotism inspires the individual to give up his other and normal income in order to accept a paid position or consulting assignment with us. Directors worthy of and commanding much greater incomes than the $17,500 figure are not available to the air lines. We have some extremely brainy and capable directors now, but how long can they be kept in the industry under our present legislation? This is something we are endeavoring to straighten out. This legislation was punitive, for reasons I shall not go into here. The indications are this situation may be relieved at least in some measure.

Reverting to the pure economics of our business, without the political (although it is difficult to discuss one phase without the other), the air lines are at the present time running at greater capacity than ever before in their history. From certain cities, particularly New York, Chicago, and Washington, it is now necessary to make reservations for certain schedules one or two days in advance. Using the average monthly figure of revenue passenger miles for 1935 as 100, the revenue passenger miles index for March of this year is 126. This is a very favorable indication of what is yet to come — and these capacity loads on certain of our schedules came to us shortly after our recent accident in the Alleghenies, during which there were air-transport passenger fatalities for the first time in ten years of service over these mountains. But even with this heavy traffic the transports cannot be full 100% of the time — due to mail scheduling, and other factors — and we are unable yet to show a profit. More than any other form

of transportation are we limited in space and weight. Unlike the railroads, busses, trucks, steamships, and to a certain extent even private automobiles, we cannot load our vehicle to accommodate safely an unusual volume of traffic, in order to help offset those trips when the traffic volume is light.

With regard to competition with other means of transportation, I have what I hope will not be construed as a "Pollyannish" attitude. I am convinced that there is room for all four media of transportation — rail, steamer, bus, and air; one supplements the other. We should be, and I hope are, friendly competitors. Our success will help the other media to succeed and apparently some of the surface carriers need help as much as we do.

A practical example of this air-line aid to other businesses took place in my personal experience several years ago: As the head of an automobile concern, I used Pan American Airways extensively in developing a certain South American market. Directly traceable to this, the sale of automobiles there increased fourfold. This immediately caused increased domestic labor, material purchases, rail shipments to the seaboard, and heavy loads of ocean freight.

It is getting so now — a definite current trend — that business men have to use the air lines in order to compete with firms in the same field of business which do use them. When this happens, the railroads, and even the busses certainly profit. The railroads, steamships, and busses have not, as yet, felt competition from us to any material extent. Our percentage of the total passengers carried is still under 2% of the traveling public. We aid many people to travel who would not do so otherwise due to the time element. This is true of vacationists who have but two weeks and would stay at home or drive their automobiles to nearby resorts, were it not for the services of the air-transport lines which allow them to visit distant home towns, resorts, and national parks within the two-week allotment. We have thus created additional business for the steamship lines, in that a traveler may fly to a seaport, take a steamer through the Panama Canal, and be back home within almost the two-week period. I know a Chicago bank official who recently started out on a two months' world tour, using rail to the West Coast, steam to the Dutch East Indies, and the air lines over a portion of Asia. If he had not used the air lines his world-tour vacation would have been impossible because of the time limitation. Instead, he probably would have driven his car to New England for the two months. Automobile executives and engineers, paradoxically, are among the best class of customers the domestic air lines have. There are, however, many occasions when they find rail service and automobile more convenient for specific trips. These few examples indicate that "there is room for all four."

There is unquestionably a stimulus and influence which our industry has had upon other industries. One angle which has always amused me is the trend of Seaboard Airline Railroad stock which many investors and speculators still consider to be that of an aviation company. If I remember correctly, this stock took a rather mysterious course several years ago when air-line and aviation manufacturing stocks were following a similar trend. It may also be pertinent to mention the manner in which railroads, automobiles, and even gas ranges, desk sets, and multitudinous other articles are now streamlined.

Few people realize that the air-line industry of the United States has been in existence but a decade. A century ago land transportation was to water transportation what air transportation today is to surface media. Today the air lines carry luxury articles large in value but small in bulk, as well as the passengers whose time is valuable. One important fundamental difference exists between air transportation and other forms. In some countries where, for any reason, rail, highway, and marine transportation have not as yet been developed, air transport has filled and is filling the entire transport need. In those parts of the world heavy freight is carried by airplane at less cost than possible by any other means. We have examples of this in South America and the Antipodes.

When our first highway was started people were skeptical whether land transportation would exist long enough to be a serious competitor to water transportation, feeling that they could not bear the expense of land carriage. Certain individuals still feel that transportation by air has as doubtful a future as was predicted for transportation by land at the time of our country's beginning.

All transportation systems have been victims of false starts. The railroad, as originally instituted, was expected to run upon an open country highway. The development of steam power made possible successful commercial two-way traffic on our waterways. The railroads required more than 30 years to obtain the mileage to which our airways grew in less than one-third of that time.

Just as economy and safety of all modes of transport depend upon the aids the government has constructed to help them, so also does economy and safety in air transport depend upon the Federal navigational aids which the government, by the 1926 Act of Congress, is presumed and supposed to construct and maintain — not alone for scheduled flying but also for the private flyer and the Army and Navy. In the early days of all transportation systems, success has been greatly hampered by discriminatory taxes and unduly burdensome governmental legislation. This now threatens our air-transport system which is already handicapped by too many regulations upon which the strangle hold of taxes is growing each year. The aviation industry, including air transport, has had over 20 Congressional investigations since 1919 — an average of more than one a year.

It is to be marveled that we make progress in spite of handicaps which no other industry, to my knowledge, has experienced in such a concentrated degree. The notoriety attendant to these investigations creates unwarranted doubts in the minds of the public about the safety of air travel. This fear complex I believe to be our "number one enemy" rather than the railroads or the busses, even though they sometimes take advantage of it by advertising: "Use the blank rail or bus line, with peace of mind, and be sure you get there."

In spite of this adverse publicity, passenger travel has increased from 5,782 passengers carried approximately 1,500,000 passenger miles in 1926, at an esti-

mated passenger revenue of $155,000, to 840,000 passengers carried 350,000,000 passenger miles in 1935, at an estimated passenger revenue of about $18,000,000. The average length of the trip of a passenger by air has increased from approximately 225 miles in 1926 to over 400 miles in 1935. In this interim of time, passenger fares have been reduced a little over 50%. We cannot charge much less with our present equipment than our present rates which average about five and one-half cents a mile. If we did, our losses would be more than they are now. Average direct operating cost of our airliners, not including sales expense, liability insurance, or other administration overhead, is between 28 and 38 cents a mile; this is for our present equipment of 10 to 14 passenger capacity. We must receive regularly about twice this 28- to 38-cent figure per mile in order to break even; therefore, rates for some time to come will not go down appreciably.

There are two ways of counteracting the fear complex: One is not to have accidents. We are working toward that end strenuously and with all means at our disposal. Fundamentally (though some will disagree with this statement) the airliner, due to its use of an additional dimension not available to surface media, is now technically, and soon will be practically, safer than any other means of transportation. It already exceeds in safety, by about twofold, cross-country travel by one's own private motor car. Life insurance actuaries are responsible for this statement and a more conservative and difficult to convince group of men never lived. We have solved the technical problems of landing in fogs; the question is now one of getting the funds to purchase the necessary equipment and expand and improve our air terminals. The airplane will, ere long, be the only method of transportation which can reach its destination on schedule under all conditions of weather. At Pittsburgh during the recent flood, air transport, for a rather extended period, was not only the sole means of transportation but the sole means of communication until radio and telephone equipment was delivered by plane. During the severe snowfalls in the Middle West this past winter the air transports arrived and departed on time and with comfort to the passengers, while the crack trains were hours late — one in particular, for the first time in history, skipped a scheduled departure. These statements are not made with braggadocio; they merely show what has happened under unusual circumstances and what, within the realms of technical practicability, the near future holds in store. Financial realization is another thing.

The air lines are facing the need for additional capital. They are handicapped in this by four factors: (1) Unwarranted fear complex, the answer to which I have already mentioned. (2) Governmental policy. We need a definite, more permanent one, so there will not be the drastic upsets and setbacks experienced during the past several years. In this connection, I should mention the valuable contribution made to the nation by the Federal Aviation Commission, of which our mutual friend and instructor, Dr. Jerome C. Hunsaker, '12, was a member. In 1934 this commission, appointed by the President, worked intelligently and diligently. Its report, although not as yet adopted in its entirety, is considered by thinking people to be a handbook or guide on American commercial aviation policy. Certain of its recommendations are being followed. I prophesy that, with certain modifications (not in principle, however), the commission's report will stand the test of time. (3) Limitation as to compensation which may be received by any one connected with the industry. This is contradictory to the American principle of fair play and honest reward, and undoubtedly will be corrected. (4) Need for airway aids and better landing facilities such as are provided by the Federal government to the water carriers and all others using harbors, rivers, and seacoasts, whether or not they be in the commercial transport business. The air is an ocean which has no boundaries nor coast lines. It is the only ocean or highway navigable to all points of the earth's surface. Oftentimes this fundamental is lost sight of.

The international phase should not be overlooked. Just as the railroad proved the most promising agency of the last century to handle the transportation needs of the American people, so in this century will the airplane prove the transport means of carrying our citizens to our far-flung frontiers. In the Nineteenth Century, our Federal government, our states, and our cities were most generous in the subsidies they granted for the construction of our railroads to, and beyond, our frontiers. So far, the present generation has not seen fit to encourage airway aids in our territories lying beyond our continental limits. The millions of square miles of virgin lands in territories such as Alaska, that invite the American pioneering spirit, would more quickly be opened to our people were our Federal government to do its duty and provide funds for aeronautical usage.

In considering rules and regulations and in considering the installation of navigational aids, our government should realize that the air is this great ocean I have previously referred to, and should make provision for the navigational aids which will make possible the accurate and safe navigation of this great ocean to all points in which this country is economically interested. Commercial aeronautics, as we know it today, was made possible by the tremendous technical advance that took place when billions of dollars were spent on the technical phases of aeronautics during the World War. Aviation does not stand alone in this respect for war-time energy likewise gave new growth to inland and foreign water transportation.

In studying the history of commercial air transport, the unbiased citizen cannot help but realize that the air transport industry owes to the Post Office Department a tremendous debt for their vision and the initial impetus given this struggling young industry. The Department of Commerce also has made valuable contributions.

As one of our outstanding air law experts states the case there are three choices ahead of us as to the trend of future legislation:

1. Assume that the present Federal aviation policy is sound and leave it alone.

2. Assume that the present form of government control is basically unsound and seek to change it.

3. Assume that the present policy is unsound, yet seek to change it only after careful study, possibly during the next Congress.

So much for the economical and the political aspects. We now turn to the scientific and technical viewpoints in which the M.I.T. Alumni are perhaps most interested. The engineering progress of the future will be towards using greater power from lighter engines using less fuel. We should be able to get greater speed and greater range of operation from the same amount of fuel, yet double our present carrying capacity when we design our future aircraft. Cost of operation will, thereby, decrease.

Probably the most interesting and significant technical development of recent years in any form of transport has been the contract let several months ago by five air lines for an experimental model of a four-engined, 40-passenger transport. The air lines joining in the financing and development of this experimental plane are: American Airlines, Eastern Air Lines, Pan American Airways, Transcontinental and Western Air, Inc., and United Air Lines. The resulting finished product, of course, would be available to other air lines at a cost considerably less than otherwise possible. This marks the first time the air lines have consolidated the experience of their engineers, pilots, and technical and traffic advisers to develop an experimental plane to meet the needs of the future and obtain an airliner with sufficient carrying capacity to insure profitable operation.

The signing of the contract followed months of conferences between the air lines and leading aircraft manufacturers to whom specifications were submitted and from whom bids were received. Specifications call for a plane weighing 25 tons fully loaded, with a top speed of 230 miles per hour and a cruising speed of 193 miles an hour, using 60% available power. The plane will have a wing span of 140 feet, an overall length of 95 feet, and a height of 20 feet. There will be four 1,000-horse power engines. The landing speed is not to exceed 65 miles an hour and the plane is to incorporate the latest features of design, construction, and navigation aids. The passenger cabin will be 40 feet long and 10 feet wide, fitted with 20 upper and lower berths with separate dressing rooms for men and women. The plane is to be capable of carrying 20 passengers and two tons of express and mail on long-distance flights, and on shorter trips 40 passengers and cargo can be accommodated. The present 10- and 14-passenger transports will not economically care for the business in prospect for 1938 when the four-engined type plane will be in service, if it meets specifications.

Approximately half a million dollars will be required for the one complete experimental airplane. If each of the five air lines had separately undertaken development of such an airplane it would have meant an additional expense to the air lines of approximately $2,000,000 — the cost of four additional experimental airplanes. It is apparent that even if five experimental airplanes had been started simultaneously, the performance, as shown by the plans of different manufacturers, would have been substantially the same. The $500,000 cost of developing the one experimental four-engined airplane and the subsequent cost of approximately $200,000 to $250,000 per airplane, could be accomplished only by the joint enterprise of these five air lines. The scope of the undertaking is such that individual development of this project would have sapped the financial resources of any individual air line.

The resulting product — and this is of major importance — will be interchangeable between air lines. In this the air lines have torn a leaf from the railroad book, in the latter's interchangeability of Pullman and freight cars. The peak season for New York-Florida traffic is the slump season for other routes. In the summer, the New York-Miami operation does not require, nor can it use profitably, the transports needed in the winter. That operator, therefore, can lease the uniform transport plane during peak season from one having a surplus of equipment and *vice versa*.

Progress is so rapid in this business, that this pending four-engined Douglas, before it is in operation, will probably be made obsolete by the design of some other manufacturer. I am convinced that "putting all the eggs in one basket," as in this case, will stimulate rather than retard design and construction of different and advanced types of airliners. The standardization of parts and accessories in the new Douglas will be an appreciable factor in keeping costs down.

Dependability is more important than speed — speed is useless without it. Scheduled trips lose their meaning if the airplane cannot keep up with the clock the year round. Adequate structural strength and dependability is the first virtue of an airplane. An airplane must meet, and does with complete safety, the worst strains it is likely to suffer. The science of designing aircraft and aircraft engines has for years been so advanced that structural failures practically never occur. Such interruptions as do occur are usually caused by minor accessory failures rather than by structural failures.

Although all development of any new form of transportation, and in fact all new developments themselves, are subject to possible hazards, the public accepts these hazards as a part of the price which must be paid for all such forward steps. We must so conduct our research and our experimental work that the probability of a repetition of an accident will be reduced to a point which, if not vanishing entirely, may be considered as acceptable in comparison with the promise of useful service.

Airways and airports are, of course, necessary adjuncts to the airliners. Airways, incomplete in their construction, have been federally provided and maintained with but few exceptions. It might be well to define just what these facilities are fundamentally: An airway is a route commonly used in air travel, usually officially designed, mapped, marked, and provided with some aids to air navigation; an airport is a landing field intended for regular use as a transfer point between air travel and travel by land or water, and provided with the necessary facilities.

Since these airways are utilized almost entirely for the facilitation of interstate commerce and for the use of private flyers and the Army and Navy, as well as air transports, it is proper that the Federal government continue to provide these facilities rather than to depend upon states and municipalities or private enterprise. In Great Britain there is a law to the effect that

no one but the national government can install or operate an air navigational aid. The greater number of airports in active use in this country are owned and maintained by public bodies. Many of those built in 1927 and 1928 are unsuitable today for commercial operation. One of the big national problems of the early 1930's was "how to grow corn on concrete highways." Now we find that some of these runways are of insufficient length for the new transports. Some of them have had schoolhouses and other obstructions built at their ends, making them useful only when conditions are favorable.

The American conception of a developed airway now includes a carefully mapped route with a sufficient number of emergency landing fields, spaced at intervals of approximately 50 miles, complete set of beacon lights (now of but little use), facilities for guidance by radio beams, and facilities for the collection, transmission, and broadcasting of local weather information.

The miles of lighted airways in operation have extended from approximately 2,000 miles in 1926 to over 22,000 miles at the present time, and lighted intermediate landing fields have grown from 92 in 1926 to over 260 at the present time. The airliners daily fly over approximately 28,000 miles of Federal airways of which 6,000 miles are not equipped with Federal airway facilities. Such equipment as does exist on the 6,000 miles is owned by the operators themselves.

The licensing of teletypewriter circuits along the airways to transmit weather and other information was begun in 1928. From zero miles of teletypewriter lines the system has grown to over 12,000 miles.

The development of radio range beacons to direct pilots under adverse weather conditions was carried forward by the Department of Commerce and reached a point justifying general installation in 1929. Range beacons have grown from approximately nine in 1929 to well over 100 in use at the present time.

The construction and operation of airways as a possible field for action by state governments has been discussed for several years, but only two states have made efforts to provide airways. Reduced appropriations and an economy wave brought the construction of airways to a complete standstill at about the end of 1932, but some small amount of construction has taken place since that date, almost all being financed from funds allocated to the Bureau of Air Commerce by emergency agencies such as WPA and ERA. Approximately $11,223,298 has been expended for construction along the Federal airways, but this does not mean and should not be interpreted as being the equivalent value of the airways. Much of the existing airway equipment, particularly radio equipment, has a high depreciation rate. Some of the equipment that was installed five, six, and eight years ago, has naturally become obsolete. It is estimated that approximately $14,000,000 is immediately required to bring the domestic airways up-to-date without giving consideration to emergency landing fields.

The weather reports furnished along the airways are the result of coöperative work between the Bureau of Air Commerce and the Weather Bureau. The expenditures by the Weather Bureau have decreased approximately 30% in the last five years, even though the volume of flying has greatly increased.

The military usefulness of the airways is of primary importance. They greatly increase the ease and speed with which our military air force can be concentrated and shifted from point to point within the United States. The airways are thus of pronounced military value, regardless of the amount of peace-time use they may receive by military flyers.

Not every city can be located upon the ocean or upon an inland waterway, but every city is located upon that one great ocean of air which is navigable to every point on the earth's surface. Some 1,300 airports are now in use in the United States, about 200 of which are used by scheduled air lines. Airports are an important phase of the public works activities of municipalities and attention should be given to the proper position, size, and condition of airports in Federal programs of aid by public works. Investment of public funds in municipal airports now totals approximately $100,000,000. The number of municipal airports was declining in 1932, doubtless due to the efforts to reduce expenditures during the depression, but since that date, an impetus has been given to the development and construction of additional airports from funds of CWA and WPA.

Great care should be exercised that this work is done well and along lines which will make the airports usable, not only when the projects are completed, but in future years. In this the WPA, coördinating with Bureau of Air Commerce airport engineers, has done wonderful work. By slight revision of the regulations to allow these projects to be accomplished under contract, relief labor might accomplish the work at lower cost and allow it to be done generally on a more economical plane. Good airports are just as important as good airplanes.

There seems to be no disposition on the part of this nation to deny that air transportation — as a promising new form of transportation — should receive some special aid until it reaches a greater degree of maturity. Eventually, of course, the air-transportation industry will be self-sustaining. Adequate transportation facilities of all kinds are important to national defense but air transportation has a special importance, differing in kind from that attached to other forms of transportation. The fact that the airplane is a weapon as well as a vehicle is not denied.

The future of air transportation is full of speculative elements, and planning for that future offers opportunity for wide difference of opinion even among the best informed. In such cases, the great significance of air transportation from a national defense standpoint must be given weight, even though national defense should not be the primary object in planning for civilian industry, even for air transportation.

Service along the busier air lines is being differentiated into express and local service, with attendant classification of airplanes into express and local stops. This development is due partly to increased traffic and a consequent desire to improve through service, partly to new equipment now coming into use, and partly to refinement in the technique of air navigation. Improved design has increased the ratio of cruising to landing speed and has extended the range of aircraft. Air navigation technique has advanced greatly during the last two years. Emphasis has been laid upon the develop-

ment of high-altitude flying to attain maximum speed and efficiency in flying. Higher altitude for cruising requires longer distance between stops. The tendency on through service is to avoid stops at intervals of less than 400 miles, and within the next two years, express airplanes may stop only every thousand miles or so. Local service at intermediate points will continue and become intensified on the heavier traffic routes. We are fortunate in having excellent planes for both express and local classes of service both in present use and under development.

Nonscheduled flying during the depression years declined as did also the number of airplanes in operation in private flying. Although the safety record in private flying has grown a trifle, it has remained with but little improvement over a period of the last seven years, while the safety record of scheduled flying during that same interval has shown a tremendous improvement.

The busier metropolitan airports will eventually be reserved for the exclusive use of the scheduled air lines. The concentration of miscellaneous commercial and private flying around air-line airports increases the type of hazards which the air lines cannot control and which interfere with the safety of scheduled arrivals and departures. Private fliers complain about this, feeling that the air-line companies are forcing them off certain airports. What is protection for one branch of flying is protection for the other. What would the future of motor boating be, if a small outboard motor boat hit the *Queen Mary* causing her, as well as the motor boat and its crew, to sink?

Airways have not kept pace with air-line expansion. The technique of flying is ahead of the airway aids. The ground radio installations are even now out of date in many instances. It is necessary to install tower antennas to replace the loop type which subject the beams to swinging. To provide "stand by" equipment for emergency use is fundamental. Traffic along the airways has increased to such an extent that the question of air-traffic control is an important current problem. A perfected and workable system, with which our chairman, Colonel Johnson, is familiar (for his department gave us valuable coöperation in its development) is now used at the main terminals and airways between. This provides, by means of predetermined flight plans, for complete and continual check as to positions of all planes along the airways. A traffic coördinating officer on the ground, who keeps track of the position of airliners, gives instructions when necessary through air-line or airport radio as to movements when planes get dangerously close together.

Present facilities are available at air-line expense to the private and military flyer. The Department of Commerce now has an appropriation to take over this work so that there will soon come into existence the needed governmental authority over airway movements. It is necessary that a central governmental authority administer this traffic control, for it involves interstate commerce and there are many interests including the Army and Navy which in peace time are subject to the traffic coördination.

In this talk all I have been able to do is cover some of the high spots. In an attempt to draw these spots together I am going to tell you a little story — a true one: A 72-year-old Chicago man left his home city not long ago and returned three weeks later. He had traveled 17,000 miles. He visited in San Francisco and Los Angeles, returned to Chicago, traveled to a point in New Jersey, went to Frankfort, Berlin, Rome, Paris, Brussels, London, and New York, and returned to Chicago. All within three weeks! Seventeen-thousand miles! He spent a greater part of those three weeks resting and visiting than he spent traveling. I do not have to tell you how this was accomplished. Think it over. Think what this means and what it will mean. Think of it in connection with what our air lines have been and are doing to keep the United States abreast and in many ways ahead of the rest of the world in both our domestic and international air transportation. Our status in world aviation must be maintained if not increased and we have an extremely difficult job ahead of us to maintain our present relative status.

There is no field in which the planning of the future needs to be carried on more continuously than aviation. Conclusions based on present conditions should be reviewed at frequent intervals and be regarded as especially flexible and subject to change. This statement is made advisedly as applying to the technical or engineering phase of our business. I repeat, in conclusion, that a more definite governmental policy as regards the air-transport industry would be beneficial from the viewpoint of the public good.

Museum of Science and Industry, Chicago

The Engineer in Transportation

BY JOSEPH B. EASTMAN

Member, Interstate Commerce Commission

I REGARD the invitation to address this dinner as one of the major honors which has come my way, because the Massachusetts Institute of Technology, as you probably know, is one of the world's great institutions of learning. It specializes in the production of engineers, and that fits in with the subject, transportation, on which I have been specializing in a way for some years. Engineers play a big part in transportation. Some might say that the locomotive engineer plays the biggest part of all, but the civil engineer, the mechanical engineer, the electrical engineer, the chemical engineer, and a few other varieties are all in the running too.

Sometimes I think that if we could make an assay of all of our professions and businesses, weighing in the scales creative ability, integrity, honor, accomplishment, and the like, the engineering profession would rank as high as any, and maybe higher. Experience with some engineers in rate-making valuation cases shakes me a little in this notion, having in mind the extraordinary differences in their testimony, dependent upon the side on which they happen to be. But perhaps they can be excused for these inconsistencies, because they are dealing in those cases with an entity or concept called "fair value," which was the product of legal rather than scientific minds, which has never been clearly defined by its creator, the Supreme Court, and which is certainly not susceptible of any very accurate measurement.

Passing over this somewhat drab page in engineering history, the other pages which relate to transportation are as bright as could be wished. The feats of engineering which made possible the construction, equipment, and operation of our 250,000 miles of railroads, over every imaginable kind of terrain, were spectacular and of the highest order. They placed the country everlastingly in debt to your profession. Yet I think that an even greater achievement has been the marvelous development in a very short space of time of highway transportation, including both the construction of the highways themselves and the creation and production of the automotive vehicles which use them. When I travel these days in the luxury of a modern airliner, I find it difficult to realize that not very far from this spot and not so very long ago I saw one of the early Wright planes take off from its catapult, make a short flight, and land on its skids, with the pilot perched on the edge of the lower wing.

Beyond any doubt, the scientists and the engineers will influence mightily the destinies of transportation. Astonishing as the progress has been, we may be sure that it will continue at an even faster rate. Here in Symphony Hall it is appropriate to suggest that the tempo is likely to accelerate from *allegro* to *presto*. Before we know it, we may find this earth of ours so small and all parts of it so easily accessible that the thirst for exploration will have to find an outlet in other parts of the universe. The Buck Rogers of the comic strips may be the harbinger of a coming era.

Coming back to earth, it behooves every form of transportation to make the best possible use of the many opportunities which the engineering profession holds out to it. The highway and air transportation industries seem to be doing a reasonably good job along these lines, but I am not so sure of rail or water transportation. About two-and-a-half years ago I requested your President, as chairman of the Science Advisory Board, to appoint a committee to coöperate with a corresponding committee of railroad executives in an effort to ensure to the railroads the maximum benefits from the utilization of modern science and engineering. Dr. Compton promptly appointed a most distinguished committee, having among its members directors of scientific and engineering research carried on by some of the great industries of the country. The railroads chose as their committee six of their leading executives; Dr. Frank B. Jewett, '03, President of the Bell Telephone Laboratories, was made chairman of the joint body.

On October 9, 1934, after nearly a year's study of the subject, Dr. Compton was able to submit to me a report to which all of these men had unanimously subscribed. It reached the conclusion "that substantial profit will inure to the railroads and to their continued development as the nation's major transportation facility if a way can be found to permit of establishing and maintaining a research organization competent to deal with the major material problems of common interest." The report also discussed the way in which the new research organization should be initiated, the qualifications which should control the choice of a director, the form of organization which should be adopted, the manner of budgeting and technical control which would produce the best results, and various incidental advantages which might be expected to flow from the new organization.

Bear in mind that this report bore the names, among others, not only of such leaders in the research field as Jewett, Kettering, Bolton, Johnson, Frary, and your own Professor Jackson, but of such railroad leaders as Willard, Atterbury, and Donnelly. The advantages of such an organization as they proposed are quite clear: The railroad industry is not getting the benefits which it should get from mass production. Too much of its equipment is custom-made. In many of the materials and supplies which it uses there is far too great a diversity of types and sizes, a diversity which cannot be supported by scientific or engineering reason. The individual railroads go their several ways and dissipate the strength in research, testing, experimentation, and

development which would be conserved and fortified by an adequately equipped central organization, one which would serve alike all of the companies, big and little, and not only keep pace with, but anticipate the progress of modern science and engineering.

Properly managed, such a central agency would not strike down individuality or imprison enterprise in rigid standards; it would equip both individuality and enterprise with knowledge and means which would enable them to function far more effectively and bring to bear the concentrated power of united action to a common end.

Nearly two years have gone by since the distinguished committee set in motion by your President reached its unanimous conclusions, but very little progress has as yet been made in carrying these conclusions into effect. The delay is not difficult to understand, because there are those, both in and out of the railroad world, who fear that a central organization for scientific, engineering, and economic research would affect their personal interests adversely. The outcome will depend upon the extent to which the leaders in the railroad industry have the ability to see it as a whole, instead of as a mere aggregation of parts; have the perception to realize how much can be gained by pulling together, instead of in a variety of directions, where interests are identical; and have the strength of purpose necessary to overcome the inevitable opposition.

I have spoken of this proposed central research agency, because it is in a way the offspring, or at least the foster child, of M.I.T. It is merely an illustration of a general principle which is capable of sound, practical, and beneficial application to our railroads in many different ways. It is, in other words, only one of numerous paths to a single goal, and it is that goal which after all is the vital thing. Of course the ultimate end is railroad success, in the broadest and best sense of the word, but the way, and the only way, to reach that end is through better service at lower prices. That is a strong assertion, and it calls for explanation. As I see it, there are two main reasons, closely related yet different, why it is true.

The first of these reasons is a general one, and it applies to the entire field of industry. It greatly concerns you who are scientists or engineers, because it has much to do with whether your efforts will prove to be of service to mankind or of actual disservice. The methods and mechanisms which you create greatly magnify the ability of human beings to perform work. In one sense they are labor-saving methods and mechanisms. The question is whether these creations are to result in less or more employment — whether they are to deprive men of livelihood, or add richly to the opportunities for life, liberty, and the pursuit of happiness.

You will agree, I am sure, that there is no more important question before the world today, and I do not pretend to know the final answer to it. I do know that a way must be found to match the tremendously increased capacity for production with a capacity for consumption which is increased in equal or greater degree — putting it in different words — to convert mass production into production for the masses. Many men who have studied this problem believe, and I agree with them, that the most satisfactory and the surest way of doing this is to see to it, if we can, that the economy and efficiency which the scientists and the engineers create are translated to the limit into terms of better and cheaper products which can be sold for prices which will bring them within range of a great popular consumption.

The great object lesson is what Henry Ford did with the automobile. Certainly the labor-saving methods and mechanisms which he and his associates created have not deprived men of livelihood but have added to the sum total of employment and human happiness. There have been other similar object lessons. To the extent, however, that there is an attempt to use the creations of the scientists and engineers, not as a means of producing and supplying better things at lower costs, but as a basis for speculative promotion or intricate, pyramided corporate structures or monopolies or other ways of diverting and absorbing exorbitant profits while prices are maintained, they will hurt rather than help mankind, and pave the way for the downfall of capitalistic society.

Even if the railroads were prosperous, which they are not, and had the transportation field to themselves, which they have not, I would still say that they ought in the general interest and in their own interest to strive continually for better service at lower rates.

This brings me to my second reason, which has particular reference to the railroad industry. That industry is faced by a necessity for better service at lower prices which is plainly evident regardless of any ideas as to general production and consumption which any one may hold. As you know, the railroads do not now dominate the transportation field to anything like the extent that once was true. They are beset by competitors on the water, on the highways, in the air, and underneath the ground. This competition has taken away a great part of their passenger traffic and important parts of their freight traffic. To a very considerable degree it is competition which cannot be bought off or driven out, because much of it springs from the power which shippers and travelers now have to furnish their own transportation without depending on carriers who operate for hire.

The facts show that this competition has already driven the railroads a considerable distance in the direction of better service and lower rates. The extent to which freight trains have been speeded up is indicated by the fact that we now find them with such names as the *Speed Witch* and the *Blue Streak*, and locomotives are being introduced which can be used interchangeably in freight and passenger service. You all know the progress which is being made with lightweight, air-conditioned, streamline passenger trains, hauled by new types of motive power. Since 1924, average ton-mile revenues have decreased about 11½% and average passenger-mile revenue about 35%. It is equally clear that the forces which have been impelling the railroads in the direction of better service and lower prices will not abate. There need be no fear that you scientists and engineers will go stale and cease your work in improving the other forms of transportation.

Mere slashing of rates to meet competition will not

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do the trick. Many railroad men who were trained in the old school have the idea, I think, that by such slashes they can kill off their competitors, as they drove the boats off the rivers in the old days, while continuing to maintain a high level of rates at noncompetitive points and on noncompetitive traffic, or even to increase that level. They will find modern competition far too pervasive, in my judgment, for any such treatment. The sound thing to do is not to cut rates regardless of costs, but to bring down the level of costs and bid all along the line for mass volume of traffic, whether or not competitors are after it.

The extent to which the country will respond to low-cost, attractive, convenient transportation has been demonstrated by what the automobile has done. The best estimates are that it has increased the travel habit of the American people fivefold. Some of the railroads are seeking the protection of the Supreme Court, because a tyrannous Interstate Commerce Commission has forced upon them passenger fares at two cents a mile. I venture to guess that before they are through they will be glad that there was a tyrant to do this. The American people will respond in the same way to low-cost, convenient, and dependable transportation of property. Any one who doubts that has only to figure the extent to which the cost of transporting raw material, fuel, semiprocessed materials, and finished goods enters into the prices which we pay for goods.

So I say that beyond a doubt the hope for a thriving and growing railroad industry in the future, able to furnish increasing employment, lies in a persistent reduction of costs which will strengthen the roads so that they can go forward with the work of improving their service and lowering their rates. For the past three years I have been laboring on this problem in the temporary job of Federal coördinator of transportation. The position will cease to exist on June 16, unless it is extended by new legislation. While not disposed to underestimate my own importance, the thing of real importance is that the idea of coördination shall survive.

Let me explain what I mean by coördination as applied to the railroads. They furnish a joint and national transportation service, but do it through a large number of separate and independent companies which have certain common interests and also certain conflicting interests. It is a fact, proven and well known, that the existence of these separate companies, as they are now conducted, causes a great deal of waste in operation and unnecessary expense. If this waste could be eliminated, it would cut costs many millions of dollars and be of vital help in the process of rehabilitating the properties and equipping them for better service at lower prices.

There are, roughly, three ways of eliminating this waste, in whole or in part. One is to promote coöperation of the companies, so that their activities may be coördinated or unified, where their common interests may be served without any real sacrifice of their conflicting interests. The establishment of a central research agency is one case in point. Gradual consolidation of companies, as in the past, might attend this process of coördination, but it would be incidental. Another way would be to promote or force the consolidation of the companies into a very few great systems. A third way would be consolidation into a single system under public or private ownership.

As the best practical solution under present conditions, I chose the first way, which I call coördination. The other ways would restrict or suppress railroad competition more than the country now desires and is willing to accept, and are open to other objections. Moreover, the numerous independent managements serve a useful purpose in intensive administration and response to local needs.

The Act which created the Federal coördinator of transportation was intended to accomplish coördination of railroads. It contained an obstacle, however, in provisions which protected the employees of May, 1933, against loss of employment or reduction of compensation. At first, these provisions were a bar to immediate economies. Latterly, their enforcement would have operated unevenly and unfairly, protecting many men but not others. This obstacle has now been removed by an agreement between the managements and the men, effective June 18, which will give men displaced by coördination or consolidation projects 60% of their previous compensation for a considerable period of time or until they can be given equivalent employment.

Taken at face value, this agreement was an epoch-making performance and a product of real industrial statesmanship. While dealing justly with the men, it gave the railroads an opportunity to realize a very considerable part of the economies immediately and the remainder gradually, but quite rapidly if business improves. It gave the men protection against temporary hardships which coördination might impose, a protection such as the employees of no other industry in this country enjoy, or even the employees of our Federal, state, and municipal governments.

It remains to be seen how the agreement will work out. The official railroad attitude is for coördination, in principle. Two years ago the Association of American Railroads was created to promote greater coöperation and collective effort by railroad managements. Yet the Association often finds it difficult to do effective work of this character, because of conflicting views and the concentration of the managements on the apparent and immediate interests of the individual roads. Some of the executives of the larger roads frankly favor large-scale consolidations and disfavor coördination. Most of them are strongly opposed to any Federal statute which would help them to bring coördination about.

The employees regard the agreement as a valuable "Hindenburg line," useful in case of retreat, but seem prepared to fight in the front-line trenches against any displacement of labor, temporary or otherwise. They profess to feel that any economies from coördination would not inure to their advantage but only provide more milk for Wall Street to absorb. Apparently they are not greatly concerned by the prospect of what the railroads may be able to do in the way of coördination without governmental help, and like the executives they do not look with favor on any Federal statute which would supply such help.

I suggest that the country cannot wisely leave the

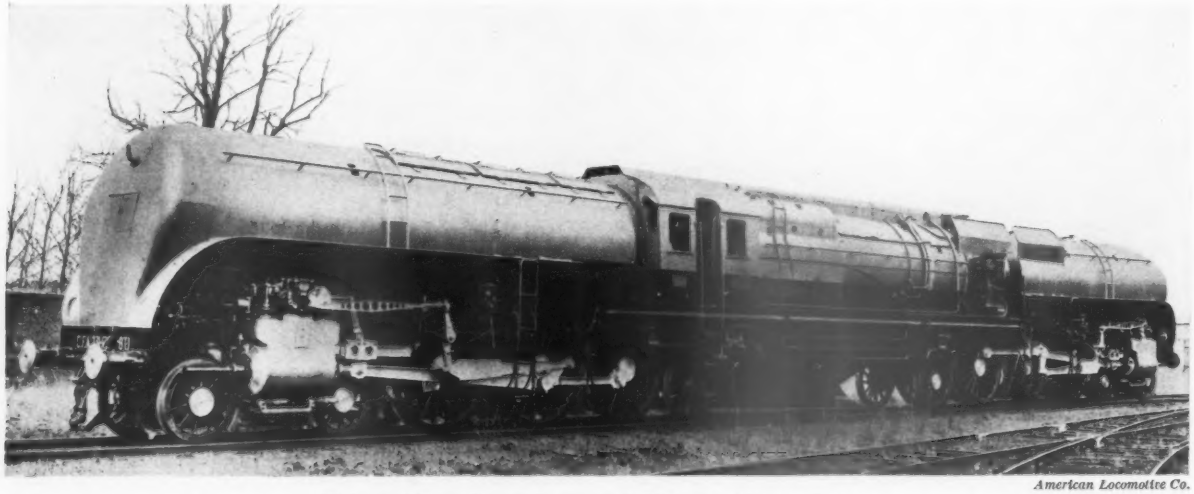
decision of this matter to the executives and the railroad labor chiefs. Theirs are by no means the only interests at stake, and they may be too close to their own interests to see them in proper perspective. Unemployment has been so widespread and its effects so disastrous to the railroad employees in the past few years that they naturally rebel against suggestions which they feel look to further contraction of jobs. There is no more important thing than the good of labor, but unless I am wholly in error as to the transportation future, that good will not in the end be served by any course of action which stands in the way of the best possible service at the lowest possible rates consistent with fair wages and good working conditions. Any such action is, I fear, long-range suicide, and no one who is a real friend to railroad labor will encourage them in it.

The railroad managements under present conditions are influenced by such a mixture of motives and emotions that I question whether they can be accepted as safe guides to a sound public policy.

What I have been talking to you about is coördination of railroads. The idea can and should be extended, of course, to embrace all forms of transportation. As a matter of fact one of the important means whereby the railroads will be able to improve their service and reduce their costs and prices will be the economic utilization, in connection with their rail operations, of both the bus and the truck. Each form of transportation is better fitted for certain operations and service than any other, and if we are to have the best national system of transportation, we must use all forms to the best advantage and at the same time discourage their use in uneconomic ways. Nor should you think that I regard coördination as the only means of improving the railroad situation. It is quite as important, for example, that the financial structures of the railroad companies should be reformed in many cases. With nearly one third of the total railroad mileage in bankruptcy or receivership, the way is open for such a reformation.

In a talk like this, I cannot come even near to covering all that ought to be covered. All that I can do is to touch upon a few salient points. The great trouble with the transportation problem is, I suppose, the same great trouble that is encountered in every other important problem. It becomes the battleground of special interests who are apt to drown out the voices of those who undertake to bring the general interest into the range of consideration. No one should or could prevent such special interests from expressing their views, but at least it can be recognized that there is a general public interest which ought also to be taken into account.

In the long run, and whatever may be done for the moment, I have a vast amount of confidence that the idea of coördination will prevail in one form or another, and in ways or by means which perhaps we do not now foresee. It will be forced upon transportation by the natural course of events, and the engineers and scientists will be important contributing factors. There is, I think, not the slightest doubt that they will continue each year, as they have in the past, to multiply the possibilities of transportation. The ground for concern lies, not with the process of multiplication, but with the process of division which must follow it. The vital thing is to see to it, if we can, that the dividends go where they will do the most good for all mankind, and that is where the forces of government should play their part. I congratulate you on what you have accomplished, I look forward to what you will accomplish in the future, and I hope with all my heart that the products of your creative minds will not be abused but used to serve and advance the lot of humanity in general, not only in transportation but in everything else.



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High-speed Beyer-Garratt locomotive built for the Algerian Railway

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

" . . . *In the Fellowship of Spring*"

Even the east wind blew benevolently on June 8, and the rhododendrons in the Great Court were still gay with blossoms, lending an obbligato *of natural color to the class pennants and umbrella tables. Where once rolled a desert of gravel, Alumni strolled across the greensward and gathered in friendly groups under the benign shade of the trees. On the Basin's edge the Sailing Pavilion was as bright and proud with flags as the* Queen Mary, *and the dinghy fleet transformed the monochromatic river into an animated pattern of polka dots. . . .*

THUS with trope and metaphor might we describe the setting of Alumni Day. Nature smiled, and, as though in gracious response, this new type of reunion, begun only last year, seemed to have reached maturity. In the solidity and importance of its serious events and in the gaiety, warmth, and good fellowship of its lighter program, Alumni Day, 1936, seemed an adequate fulfillment of the hopes of those who have championed the plan. To last year's committee who laid the foundation under the direction of Hamilton L. Wood, '17, and to this year's committee who so happily brought the plan to fulfillment under the direction of Harold B. Richmond, '14, is due an accolade from all those who cherish the Technology spirit and who wish to see its vivifying influence extended throughout our alumni body.

Let the statistical facts of the day be recorded, although they are quite inadequate to suggest how successful the program was in terms of sociability, enthusiasm, and that morale, or "breath of life," about which President Compton spoke in his commencement address (see page 414).

In all, 750 people actually registered on Alumni Day, but there were many who did not, and 1,500 would be a reasonable estimate of the number who attended all or part of the program. At the dinner in Symphony Hall there were 628 and in addition there were 622 seats in the balconies filled for the speaking program and concert, bringing the total attendance at Symphony Hall to 1,250. There were approximately 100 wives of Alumni present during the day.

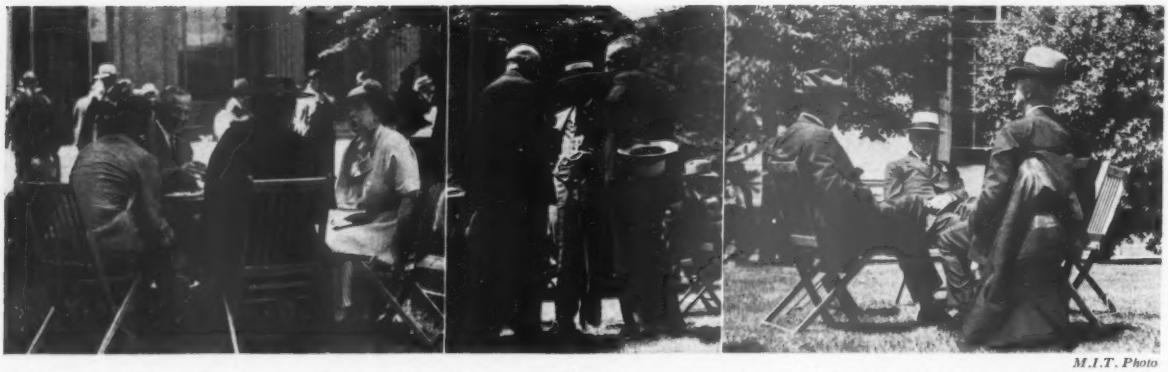
One of the most pleasant of all of the events was the luncheon in Du Pont Court, and the class day exercises of the senior class, which followed this luncheon, were an effective addition to the Alumni Day program. These various outdoor events emphasized, perhaps for the first time, the superb setting which the Institute offers in its courts for gatherings of this sort.

Elsewhere in this issue we present the complete proceedings of the Transportation Conference in the morning, and the material attests to the importance and value of the conference. In spite of the Republican National Convention, the papers presented, together with Mr. Eastman's speech in the evening, received wide notice in the press. We hope very much that this idea of having as a part of the annual reunion program a serious and solid conference of this kind will be continued. The dedication of the boathouse and the sailing regatta in the Basin were an effective demonstration of the increased scope of extracurricular activities at Technology.

Certain changes in emphasis would, perhaps, be desirable in future Alumni Days, although the basic plan employed this year seemed eminently successful. All of the serious and heavy material should be concentrated in the morning conference and the evening dinner given over entirely to pure entertainment. It would seem desirable to have some event early in the morning to draw the Alumni together immediately and to act as a focal point for those who do not desire to attend the conference. The program for the women can, doubtless, be extended; certainly there should be a program for wives of

M. I. T. Photo

Scenes in the Great Court on Alumni Day when members of the Senior Class and their parents joined with Alumni in Class Day exercises. Included in the program was the christening of the dinghies by Miss Jean Compton, daughter of President Compton, and the welcoming of the seniors into the Alumni Association by Edward L. Moreland, '07, retiring President of the Association



M.I.T. Photo

Groups at the Alumni Day luncheon. Left. *President Compton and Mrs. Compton (in white) at a table with Redfield Proctor, '02, and Mrs. Gertrude S. Hinckley, '10.* Center. *Edwin S. Webster, '88, Dean Vannevar Bush, '16, and Treasurer Horace S. Ford.* Right. *Gerard Swope, '95 (center) and Franklin A. Park, '95*

the Alumni. The committee is studying the relative advantages of Saturday and Monday; there are desirable features attached to each of these days, but the controlling factor will be the class reunions. These reunions this year were notably well attended; 1911, 1916, and 1926 drew unprecedently large attendance.

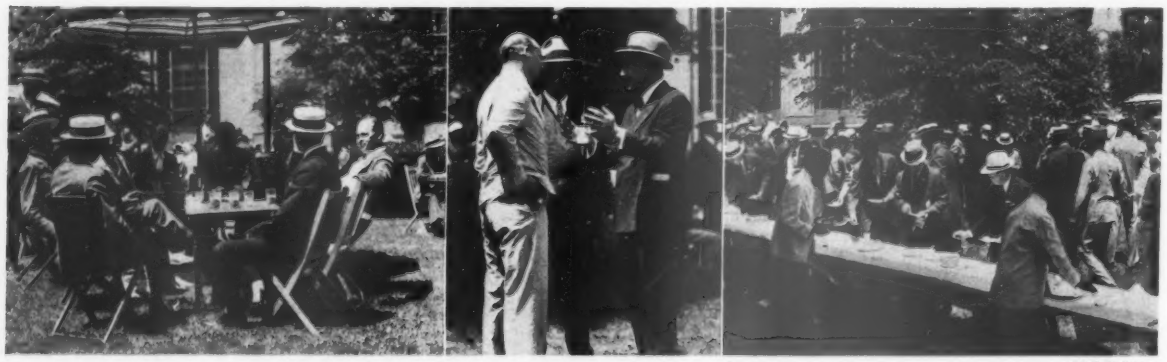
That Alumni Day should be a permanent part of the assembly program is beyond question. In the words of President Compton, the program of June 8 "set a standard which it will be difficult to carry on, and there is no doubt but that the welfare of the Institute was markedly advanced by the success of this Alumni Day." We are confident that the committee in charge next year will consolidate the gains that were made this year and will add to the importance and usefulness of the reunion.

Presentation of Dr. Tyler's Portrait

WE present on the next page a reproduction of the portrait of Harry W. Tyler, '84, painted by Isaac B. Hazelton, '94, and presented to the Institute on Alumni Day in the presence of a large group of Dr. Tyler's classmates, former colleagues, and friends. The presentation was made by Samuel C. Prescott, '94, Dean of Science, and Henry B. Phillips, Head of the Department of Mathematics, accepted the portrait.

Said Dean Prescott: "No occasion could be more fitting for the presentation to the Institute of a portrait of a distinguished Emeritus Professor who has rendered long and conspicuous service to his Alma Mater than an Alumni Day, when he can share by his presence the numerous events, surrounded and attended by his former colleagues and receiving their warm congratulations, and heartily welcomed by some of the hundreds of his former students. It was their generous action, indeed, inspired by their high regard for their brilliant teacher, that has made this event possible and an important one in our day's program. Their prompt and spontaneous response to the suggestion that Dr. Tyler's portrait should adorn this room was ample evidence of the great respect and affection in which he is held by his former students.

"It is unnecessary for me to tell any group of Technology men and women who Harry W. Tyler is. They all know that he was a member and leader in the Class of '84, a high-ranking student (and graduate of the Course) in chemistry, but who for pure pleasure and love of learning took all the advanced courses in mathematics given in the Institute in his day. Even with these scholastic labors he found time to indulge in the student activities of his day and to serve on the editorial staff of *The Tech*, which was started in 1881–1882, and in his senior year, 1883–1884, was president of the board of directors. He taught mathematics for three years following his graduation, then having happily induced his classmate and fellow chemist, Miss Alice Brown, to become Mrs. Tyler, they spent two years in travel and study abroad at Göttingen and Erlangen.



M.I.T. Photo

Other groups in Du Pont Court. Left. *1916 Table.* Center. *Jerome C. Hunsaker, '12, Paul W. Litchfield, '96, and Edward P. Farley*

This portrait of Harry W. Tyler, '84, painted by Isaac B. Hazelton, '94, was presented to the Institute on Alumni Day (*see opposite page*)

"Those Alumni of my own student period know him as the secretary of the Institute, combining in one individual the trinity of offices known to more recent students as registrar, admissions office, and secretary of the Faculty, to which positions he was literally drafted by President Walker. Had deans been at that time extant, he would probably also have been dean. How well some of us may remember the brief note 'Please see me. H. W. T.' in his characteristic, small handwriting with which he summoned any student to his office, and the businesslike yet always courteous and kindly manner with which the matter in hand was considered.

"We older Alumni knew him at a time ten years later as the champion of the autonomy of the Institute, fearlessly and logically and successfully supporting the position of those who believed that in Technology's independence lay the road to success. We recall how in days of financial stress that followed he used his great organizing ability and constructive thinking as a tireless worker for its upbuilding and strengthening. Today he has but to look about him to see some of the fruits of that for which he labored, and I feel sure finds in the Technology of the present the reward for all the efforts extended in its behalf.

"As chairman of the Walker Memorial Committee, he guided the campaign which brought into existence the splendid student center which has served so admirably for a score of years, and with such constantly increasing use that its enlargement is now greatly needed. It was an especially happy thought of the artist that the memory of this service should be perpetuated in the suggestion of Walker Memorial painted in the background of the portrait.

"We knew him as the Head of the Department of Mathematics, brought under his wise guidance to a position of the very first rank in this country.

"We here at M.I.T. know him as the prime mover and perennial president of the Faculty Club for many years, a position in which his gifts as a presiding officer and the flashes of his scintillating humor carried us to new heights of admiration and regard. We know him as an intrepid mountaineer and lover of those vast natural scenes of beauty and grandeur which delight and inspire; as an ardent traveler, who finds enjoyment in surveying the manners and customs of other peoples; and as a student of educational problems. . . .

"With ever deepening appreciation, we who have long been at the Institute think of him as a conscientious and thorough teacher, with sincere and friendly interest in the student's welfare, as a virile, constructive force in the determination of faculty and Institute policies, and, best of all, as a steadfast and cherished companion and friend, and as a man of unsullied character.

"Perhaps my inadequate characterization may indicate why this portrait is before you. Obviously it is because of what he has done and because of our regard for the man who has all these qualities which so exemplify the traits we wish might be developed in every student that it gives the Committee the greatest pleasure to present to the Institute, to keep for all time, for the constant inspiration of student and staff members, this portrait of Harry Walter Tyler.

"We are proud that its artistry has been executed by a master who is also a Technology man and a former student of Dr. Tyler's. This means that the artist has mixed his pigments not merely with skill and with brains, as legend tells us one of the old masters claimed to do, but also with appreciation of character, respect, and affection. We are happy that Ike Hazelton, '94, is here today among the many who have come to honor their Alma Mater.

"At this moment one circumstance leaves its deep shadows of regret and disappointment in our hearts. It was originally intended that Professor Augustus H. Gill, '84, chairman of the Tyler Portrait Committee, should stand in my place today and make the presentation of this portrait to the Institute. No one else could do it so well as he. For the 56 years since Dr. Tyler and Dr. Gill entered the Institute as freshmen, they have been almost constantly associated in educational work either as students or teachers, and have been warm and devoted friends. It was, therefore, specially appropriate that Dr. Gill should have been spokesman today. Unfortunately his illness prevents him from enjoying this deserved honor and high privilege. His remarks would have been, I am sure, inspired with the admiration and regard that a half century of comradeship can well engender, and since they worked side by side through the four undergraduate years at the Institute, as well as in the whole period since those days, there might be more of personal allusion to the student days than I can offer. But may I, who have been both student and junior associate, speak as one who still retains all the deep respect and a trace of the awe of the student for his master, although for 30 years the awe has been largely replaced by increasing admiration for a great colleague. . . ."

Graduation

NEWTON D. BAKER, Secretary of War in the cabinet of Woodrow Wilson, was the orator at the Commencement Exercises which marked the 75th anniversary year of the granting of the Institute's charter at Symphony Hall on the morning of June 9. He spoke without prepared manuscript or notes on the subject, "Science and Politics."

A total of 532 degrees, of which 380 were bachelors, were conferred by President Compton. Advanced degrees included 24 doctors of philosophy, 17 doctors of science, and 111 masters of science. This year, for the first time, the smaller illuminated diplomas, encased in red morocco binders, were given.

The academic procession of the guests of honor — the Corporation, members of the Class of 1886, the officers of the Class of 1911, and the Faculty — was again led by Chief Marshal Alexander Macomber, '07. He was followed by President Compton; Mr. Baker, escorted by Vice-President Bush,'16; the Reverend Dana McL. Greeley, minister of the Arlington Street Church, who gave the invocation and who was escorted by Professor Charles E. Fuller, '92, Chairman of the Faculty; General Fox Connor, Commanding General of the First Corps Area and of the First Army, escorted by Colonel Samuel C. Vestal; Captain E. R. Norton, '13, representing the United States Navy, escorted by Professor James R. Jack; and Mayor John D. Lynch of Cambridge, escorted by Professor Harry M. Goodwin, '90, Dean of the Graduate School.

Following the guests-of-honor division of the procession came four members of the Faculty who retire this year: Professors James L. Tryon, George B. Haven, '94, Thomas Smith, and Nathan R. George; and 29 members of the Corporation, marshaled by its Secretary, Walter Humphreys, '97.

Dr. Samuel C. Prescott, '94, was marshal of the Class of 1886, celebrating its 50th reunion, and those who marched in this division were: Charles F. Richardson, Dana P. Bartlett, Major Frank S. Wilson, Charles H. Woodbury, Robert Coit, Henry A. Howard, Charles H. Herrick, Henry B. Alden, and Dr. Alice G. Bryant — all of Boston — Louis F. Cutter, Henry P. Benson, and Ambrose Walker of Salem, Mass., Arthur T. Chase and George P. Aborn of Newton, Mass., William K. Campbell of Wollaston, Mass., Birney C. Batcheller of Wallingford, Vt., Arthur G. Robbins of Winchester, Mass., Fred A. Whitney of Leominster, Mass., Charles E. Holmes of Lynn, Mass., David Van Alstyne of Wilton, N. H., William F. Dawson of Hollis-ton, Mass., Howard G. Noble of Westfield, Mass., D. Lewis K. Hathaway of Warren, Mass., James T. Ball of Still River, Mass., John W. Killinger of San Francisco, Calif., and Walter R. Ingalls, William H. Chadbourn, Fred E. Foss, and Theodore Stebbins — all of New York City.

The officers of the 25-year class, 1911, Donald R. Stevens of Passaic, N. J., and Orville B. Denison of Worcester, Mass., marched at the end of the 50-year class division. The faculty division, composed of 113 members of the Staff of various Institute departments, had as marshal Professor George E. Russell, '00. Leading the long procession of candidates for degrees were John C. Austin of Spokane, Wash., President of the Class of 1936, and the three class marshals — Brenton W. Lowe of Fitchburg, Mass., Fletcher P. Thornton, Jr., of Summit, N. J., and Anton E. Hittl of Melrose, Mass.

In his address to the graduating class President Compton said in part: "It was about 300 years ago that Francis Bacon wrote: 'That which man altereth not for the better, Time, the Great Innovator, altereth for the worse.' This is a universal truth, as true today as 300 years ago and as true of you men individually as it is of a business organization, or a farm, or a building. The only recipe for avoiding decay and stagnation is ever to press onward, endeavoring to alter yourselves and your circumstances for the better. . . .

"'The breath of life' is a wonderful symbolism for that which makes the difference between the nonliving, or dead, and the living. It symbolizes all that is creative, lovable, and most precious in this world. The French have the phrase *esprit de corps*, *i.e.*, breath (or spirit) of the body. We have the equivalent word morale.

"If I could select any virtue to endow you with at this time, it would be this 'breath of life' that we call morale. It includes courage, honesty, cheerfulness, persistence, coöperativeness, sportsmanship, and all those virtues which are the mark of success in one's own inner life and also in one's social relationships. When the Lord fashioned Adam, the body and all its organs were not enough to constitute the living man; the breath of life was needed. Though your parents, teachers, and associations have given you bodies and brains and a certain amount of skill in the use of both, you are not really desirable and productive units in society unless you also possess morale. Without it no one will like to have you around; no employer will desire to retain your services; you will be a failure in society and in yourself.

"Nations are strong and their people happy when their morale is high, even though troubles beset them. It is their morale which has been the secret of strength of religious sects. It was lack of morale, due to disinterest and distrust, and not lack of equipment or fundamental bravery, that led the Portuguese army to break before the German attack at a critical time in the Great War. A ball team, or a business organization, or a college is made or wrecked by morale. It is not success which creates morale but morale which creates success. A man with bad morale in an organization is like a pestilent infection and almost no amount of ability or even genius can compensate for it to make him a desirable member. . . .

"So in conclusion, my friends, keep your morale high. Avoid as you would a deadly plague any tendency to let it slip. Maintain faith in yourselves even in face of discouraging circumstances. Be unselfishly coöperative, without being a 'yes' man. Make a positive effort to foster those personal and organizational contacts which will give you zest, enthusiasm, moral support, and professional growth. Keep in touch with the Institute through our Alumni Association, your Class, your Professors, and the placement office. You can do much to maintain your morale through conscious effort. My

parting word to you is, therefore: 'Keep up your morale: inhale deeply and continually of this magical breath of life.'"

New Members of the Corporation

THE election of three new Life Members of the Corporation was announced by President Compton at the meeting of the Institute's governing body on June 8: Godfrey L. Cabot, '81, President of Godfrey L. Cabot, Inc., Boston; Philip Stockton, '99, President of the First National Bank of Boston; William C. Potter, '97, Chairman of the Board, Guaranty Trust Company, New York City.

In addition to his many business and industrial affiliations Mr. Cabot has long been interested in aeronautics. He was president of the Aero Club of New England from 1915 to 1929, and later became vice-president of the Aero Club of America. He is a trustee of Norwich University and president of the National Gas Products Association, the Wak Company, the Cabot Gas Company of New York, and the Service Gas Company of Pennsylvania. He is also treasurer of the New England Watch and Ward Society, vice-president of the Texas Elf Carbon Company, member of the executive committee of the United Carbon Company, and a director of the Carbon Black Export, Inc.

After being graduated from Technology, Mr. Stockton joined the Merrimac Chemical Company at Huntsville, Ala. He later was elected treasurer of the Lowell Bleachery, 1901; president of the City Trust Company, Boston, 1902; president of the Old Colony Trust Company, Boston, 1929; a director of the American Telephone and Telegraph Company, American Sugar Refining Company, General Electric Company, Ludlow Manufacturing Associates, New England Mutual Life Insurance Company, Pacific Mills, and others. He is also a trustee of the Boston Five Cents Savings Bank.

Mr. Potter was graduated as a mining engineer, a field in which he had wide experience before entering banking. He was general manager of the Guggenheim Exploration Company, Mexico City, 1902 to 1905; general manager of the Inter-Continental Rubber Company, 1911 to 1912; vice-president of the Guaranty Trust Company of New York, 1912 to 1916; partner, Guggenheim Brothers; vice-president of the Chili Copper Company, and president of the Braden Copper Company, 1916 to 1921. He is a member of the American Institute of Mining and Metallurgical Engineers and the Newcomen Society and a director of the Anaconda Copper Mining Company, Atchison, Topeka and Santa Fe Railway Company, Continental Baking Corporation, Continental Oil Company, Discount Corporation of New York, Electrical Bond and Share Company, and the International Agricultural Corporation.

Finance Committee Changes

THE resignation of Francis R. Hart, '89, as chairman of the finance committee of the Corporation, a position he has occupied for twenty-six years, was announced last month. The growing responsibilities of his business affairs and the belief that a younger man should take over his duties were given by Mr. Hart as the reasons for his resignation. His place on the committee will be filled by Philip Stockton, '99, President of the First National Bank of Boston and new Life Member of the Corporation, who brings to the committee long and valuable experience as a banker.

Mr. Hart, who is president of the United Fruit Company, has been a member of the Institute's Corporation since 1907, when he was elected treasurer, and he was elected a Life Member of the Corporation in 1909. Mr. Hart's first term as treasurer continued until that year, and in 1913 he was again elected treasurer, serving until 1921. He has been a member of the finance committee since 1910, and has given much time and thought to the affairs of Technology in the intervening quarter of a century. Although he now gives up his duties on the finance committee, Mr. Hart will retain his membership on the executive committee of the Corporation.

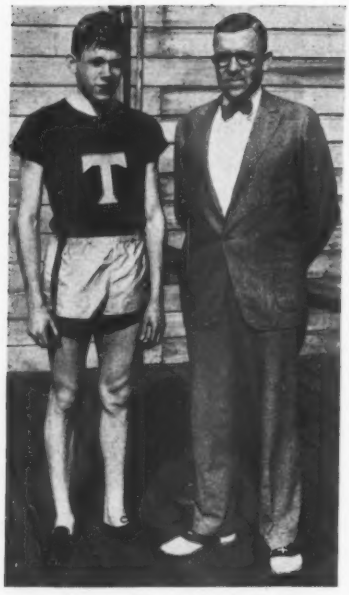
Mr. Hart was a member of the Class of 1889 at Technology and upon leaving the Institute he divided his time between work on the engineering staff of the Massachusetts Electrical Engineering Company and engineering work on the plantations of the Boston Fruit Company in Jamaica, West Indies. A few years later he became general manager of the Cartagena Terminal and Improvement Company, Ltd., and the Cartagena-Magdalena Railway Company in Colombia, South America. From 1893 to 1906 he was president of these companies and managing director of the Compania Fluvial de Cartagena, an associated organization. In 1896 Mr. Hart was elected a vice-president of the Old Colony Trust Company, later becoming vice-chairman of the board.

Aside from his numerous business interests, Mr. Hart is well known as an authority on the cultural and economic history of the Central American Countries and the Caribbean Sea, and is the author of three well-known books which grew out of his research in the history of the Caribbean. They are "Admirals of the Caribbean," "The Disaster of Darien," and "The Siege of Havana." He is also the author of many monographs and historical articles.

Piping Radio Waves

A SIMPLE and efficient method of communication in which ultrahigh-frequency radio waves are transmitted through a hollow metal pipe in much the same manner as the human voice travels through a speaking tube has been developed in the communication laboratories of the Institute by Dr. Wilmer L. Barrow, '29.

This electromagnetic "pipe line" opens new prospects for the transmission of television, telephone, and telegraph signals at high efficiency. The commercial application of the system, however, must await the development of apparatus for the generation, amplification, and utilization of the extremely short radio waves, a vast and relatively unexplored field of communication. While radio broadcasting stations use waves hundreds of meters in length in a highly congested region of transmission channels, the hollow-tube method



Stanley T. Johnson, '36, Captain of the Track Team, with his father, "Doc" Johnson, a figure familiar to alumni followers of track. Johnson holds all the M.I.T. records in the broad jump

operates on waves only a few hundredths of a meter long. Theoretical expectations have been confirmed by successful laboratory experiments in which the voice was transmitted through a tube, picked up at the opposite end, and reproduced on a loud speaker.

In this method the radio waves travel within and on the infinitesimally thin "skin" of the inside wall of a hollow metal tube without interference from external signals or static. The simplicity, economy, and ruggedness of the system is indicated by the fact that, unlike conventional wire and cable systems, this tubular conductor requires only external mechanical support, and the energy losses which usually occur in insulators are absent. This contrasts strikingly with the complex problem of insulation in the ordinary cable in which each individual wire must be carefully separated from its neighbor by paper or other forms of insulation. The rate at which the signals lose strength as they progress down the conducting tube is slightly greater than on conventional telephone cables. Calculations indicate, however, that signals transmitted through the tubes for long distances could be amplified at various stages.

Another feature of the system is that the end of the conducting tube may be flared to form an electromagnetic horn to send directive radio waves into the atmosphere in much the same manner as an acoustic horn produces a beam of sound. The hollow tube may also be used as a filter to cut out low-frequency signals.

Transmission of television signals from point to point or between cities offers a most promising field for this electromagnetic pipe line, provided apparatus capable of utilizing the very short waves can be developed for general commercial use. The unusual characteristics of the method are well adapted for transmitting the wide-frequency range demanded by television. The tube system of transmission also opens up stimulating prospects in other fields, including the possibilities of its use in direct broadcast or as a connecting link between the sending apparatus and antenna, or perhaps as the antenna itself in the form of an electromagnetic horn. Indications are that the hollow tube is better suited to the transmission of one centimeter waves than wires or cables.

The new system as it has been developed at Technology consists of the conductor tube, a transmitting terminal device, and either a receiving terminal unit or a radiating end, such as the electromagnetic horn already described. A short coaxial conductor, a wire at right angles to the axis of the tube, a parabolic reflector, and other arrangements of conductors may be used as terminal sending and receiving devices.

Dr. Barrow announced this important new development simultaneously with a similar announcement by the Bell Telephone Laboratories where the same method of communication was independently discovered.

A Record of Records

COMMENCEMENT DAY, June 9, brought to a close the athletic career of Stanley T. Johnson, '36, as a wearer of the cardinal and gray of M.I.T. In his four years of intercollegiate competition, Johnson has scored the amazing total of 206 points — the largest number of points of any athlete ever to represent an Institute track team. His specialty was the broad jump, although in dual meets he has scored in both the high and low hurdles.

All of the Institute records in the broad jump for both the varsity and freshmen are now held by Johnson. As a freshman, his best effort was 22 feet, two-and-a-half inches. As a junior, he leaped 24 feet, two inches, establishing the varsity out-door record. His best records for indoor competition are 21 feet, three-and-a-half inches, and 23 feet, four and three-quarters inches, respectively, for freshman and varsity records.

In both the indoor and outdoor intercollegiate championships, Johnson has been a stellar performer, competing in his specialty. At both meets, for three years, he has won the broad jump once, placed second twice, and third, three times — a remarkable record of consistency.

In the summer of 1935, he won the broad jump in the Junior National Amateur Athletic Union Championships held in Nebraska, with the exceptional distance of 24 feet, 11½ inches — his best jump in competition. He will try for a place on the 1936 United States Olympic team in the running hop, step, and jump. Last summer he tied for second place in this event at the Amateur Athletic Union meet with a jump of 48 feet, six inches.

Super Analyzer

A GRANT of $85,000 from the Rockefeller Foundation will enable the Institute to begin construction of a new and more powerful analyzing machine called a differential analyzer. As projected by Dean Vannevar Bush, '16, the new analyzer will be built under the direction of Professor Samuel H. Caldwell, '25, and a group of associates in the Department of Electrical Engineering.

The present analyzer, which was built several years ago, has proved extremely valuable in various problems of analysis at the Institute, and has been constantly available for the solution of many complex engineering and scientific problems in widely diversified fields. Three similar machines, built with the aid of plans and advice made available by the Institute, are now in operation or under construc- (*Continued on page 418*)

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THE INSTITUTE GAZETTE

(*Continued from page 416*)

tion in this country and Europe. One is at the University of Manchester, England, another at the Astrophysical Institute of Oslo, Norway, while the third is at the University of Pennsylvania.

Improvements in design on which Dr. Bush and his group have been working during the present year under a preliminary grant from the Rockefeller Foundation promise even greater precision, flexibility, and scope.

Prize Theses

MISS PHYLLIS M. NEEDHAM, '36, a graduate in Architectural Engineering, received the first prize offered by the Institute chapter of the Society of Sigma Xi, national honorary scientific society, for the best undergraduate thesis submitted toward the degree of bachelor of science. Her subject was "A Study of the Stratification Effect of Concrete." The second prize was awarded to Dudley A. Williams, '36, of the Department of Chemistry for a paper on "The Vapor Pressure of Nitrogen Dioxide," and third prize went to Morris Sorkin, '36, Electrical Engineering, who submitted a thesis on "Realization of a Band Pass Filter at Broadcast Frequencies." Honorable mention was made of Edward L. Pratt, '36, of the Department of Biology and Public Health, for a paper entitled "The Growth of Microörganisms on Media Exposed to Ultraviolet Radiations."

Miss Needham has been an active member of the Drama Shop during her undergraduate career. Mr. Williams was awarded his degree in December, 1935. Mr. Pratt was awarded his "T" for crew activities, and has been a member of the staff of *The Tech*, as well as Phi Beta Epsilon fraternity and Delta Omega, the honorary biological society.

Stratton Prizes

WINNERS of the Stratton Prizes, which are awarded for the most effective preparation and presentation of scientific papers by members of the undergraduate professional societies, were: first, Melvin W. First, '36; second, Edward C. Peterson, '37; third, Joseph Ackerman, Jr., '36.

The winning paper by First, who was graduated in Biology and Public Health, was "Control of Tuberculosis." Peterson, a junior in Mechanical Engineering, read a paper on "Cement Casting." Joseph Ackerman, Jr., who has been a student in the Chemistry Department, presented a paper on "The Direct Use of Latex in the Manufacturing of Rubber."

The judges were Dr. A. C. Dieffenbach of the Boston *Evening Transcript*, Mr. J. C. Hogg of Phillips Exeter Academy, and Colonel S. C. Vestal, Head of the Department of Military Science.

Henry Adams Morss, '93 (1871–1936)

IN the midst of preparing statements concerning the death of his classmate, Albert F. Bemis, Henry A. Morss found it necessary to go to the hospital for an

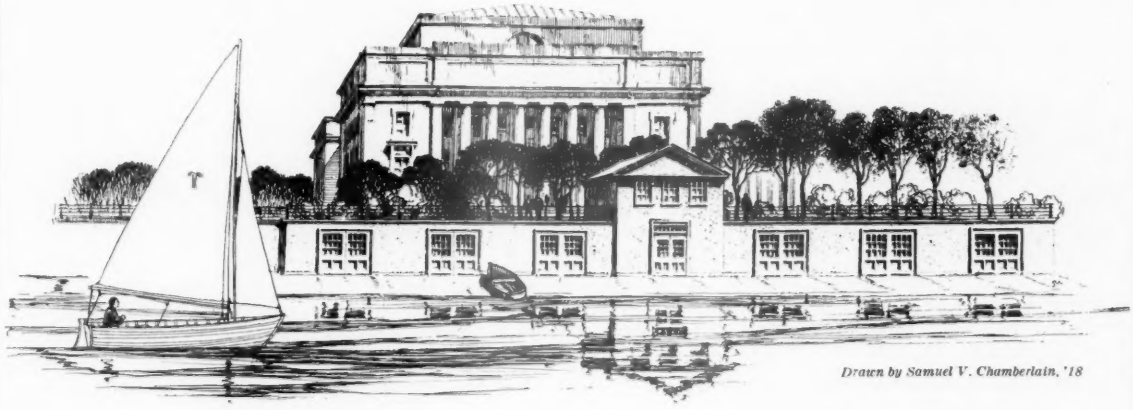
operation from which he did not recover. His death occurred on May 6, not a full month after Mr. Bemis'. The Review shares with the Corporation of the Institute and with the alumni body the sorrow that is felt, and wishes to voice its tribute.

Mr. Morss's capabilities were diversified and his interests far reaching. To his Alma Mater he made valuable contributions, perhaps the most important as Corporation member and assistant treasurer. He began membership on the Corporation under term election in 1911, the first of his Class to fill this position, was re-elected in 1919, and in 1924 became a life member. He ably assisted his brother, the late Everett Morss, '85, Treasurer of the Institute for many years, in the financial administration of Technology, and was assistant treasurer for two terms between 1920 and 1934. In the latter year he became acting treasurer, a position he held until the election of Horace S. Ford as treasurer in the summer of 1934. Recently he served as an interim member of the Corporation executive committee.

As an undergraduate in the Department of Electrical Engineering Mr. Morss had been an active member of Theta Xi, and a member of K.O.S. and the Tech Electrical Club. It was perhaps natural, but none the less generous, that his graduate interests did not exclude Technology: In 1909 he was a member of a committee of three who investigated the advisability of initiating an aeronautical course at the Institute; he was president of the Alumni Association in the year (1918) when Walker Memorial, a project in which he was much interested, was dedicated as the center of student activities; he served with notable success as a member of the Alumni Council. In 1923–24 he was a member of the Corporation's Visiting Committee to the Department of Military Science and Tactics, and in other years served on similar committees for Naval Architecture and Marine Engineering, Aeronautical Engineering, and the Nautical Museum, the progress and prestige of which were strongly influenced by his wise judgment and enthusiastic support. In 1930 he was a member of the inauguration committee which planned the dignified induction of President Compton, and he was, in 1935, a charter member of the Research Associates.

In the industrial field Mr. Morss started work in the factory of Morss and Whyte, and throughout his life he maintained his connections with that concern and with others which developed from it. In 1918 he became treasurer of the Simplex Wire and Cable Company, Simplex Wire and Cable Company of California, Simplex Electric Heating Company, and the Morss and Whyte Company. Later he was made president and director of the Simplex Wire and Cable Company of Cambridge, and was also trustee of the Morss Real Estate Trust, trustee of Radcliffe College, and a director of the Hub Wire Cloth and Wire Company and of Arthur D. Little, Inc.

Business and the Institute did not absorb all of his energies: He was a former president of the Boston Children's Friend Society; treasurer of the Old South Society; member of the American Institute of Electrical


Drawn by Samuel V. Chamberlain, '18

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Engineers, American Society of Mechanical Engineers, and of the Union, University, and Exchange clubs of Boston. An enthusiastic yachtsman, he was a member of the Eastern, Corinthian, and New York Yacht clubs. At different times he owned some 20 boats and yachts of various sizes and types with which he took part in many races; these included two races to Bermuda which he won in his class. This delight in the wind and water found an unselfish outlet of benefit to the students at Technology: Mr. Morss, at the time of his death, was a member of the committee which superintended the building and launching of the fleet of dinghies whose fresh white sails on the Charles will be remembered by those who attended Alumni Day this spring.

Arthur Amos Noyes, '86 (1866–1936)

ARTHUR AMOS NOYES, one of the most distinguished Alumni of the Institute, died on June 3 at his home in Pasadena, Calif., from the effects of pneumonia. He had returned only recently from the Mayo Clinic at Rochester, Minn., where he had undergone treatment for another ailment.

Born in Newburyport, Mass., on September 13, 1866, Noyes with his boyhood companion, Samuel Mulliken, developed a strong interest in chemical science. Together they experimented in all seriousness in their home laboratories, even working through such substantial volumes as Eliot and Storer's texts on chemistry and on qualitative analysis. In retrospect, it seems as if both Noyes and Mulliken were destined to pursue their higher education in the Institute of Technology, which, 60 years ago, as a new type of school for science and engineering was gaining fame daily. To this school they came about the year 1883, where organic chemistry became one of their main interests. At the end of their course they journeyed together to Leipzig to study further their chosen subject under Professor Wislicenus.

Soon their paths of scientific pursuits began to deviate. Noyes became more and more interested in physical chemistry, the newly recognized discipline of the science. Ostwald, destined to become the great protagonist of this new kind of investigation, had been in charge of the work at Leipzig for a year, and in that short time he had attracted to his laboratory both the Swedish chemist, Arrhenius — with his electrolytic dissociation theory — and the Dutch chemist, Van't Hoff, famous for his theory of stereochemistry and for the discovery of the laws of chemical dynamics and osmotic pressure in solution. Among the associates of Noyes at that time were Nernst and Haber, both to be awarded the Nobel Laureate in later years.

After receiving the doctorate in 1890, Noyes returned to the Institute as an instructor in analytical and organic chemistry. In 1894 he was made an assistant professor, teaching mainly in the field of organic chemistry. It was not until 1899 that he became professor of theoretical chemistry and was launched definitely on the highway, leading, in 1903, to the establishment of the Research Laboratory of Physical Chemistry, the first research laboratory of the M.I.T. and the first, in the United States, to be devoted to physical chemistry.

Professor Noyes remained as director of this laboratory for 17 years. During this time there came to him many students, among whom were at least a score of men who in their turn were to rank among the most distinguished chemists in the United States.

In 1920, after long consideration, Professor Noyes withdrew from the Faculty of the M.I.T. to become director of the Gates Chemical Laboratory of the California Institute of Technology. He saw in this new school a great opportunity to put into practice his cherished ideals in education, namely, of early *selecting* the ablest students, of *interesting* the honors group thus obtained in discovery, and of *training* them in research while they were still undergraduates. In other words he was planning to build up in undergraduates a background of research experience which would make for abler and more deeply interested graduate students who at the end of their advanced training would be outstanding as investigators in industrial research laboratories, in educational institutions, and in the scientific bureaus of the government.

During the half century covered by the period of his active researches, Professor Noyes investigated prob-

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lems of reaction velocities, thermochemistry, chemical equilibria, qualitative analysis of the rare elements, and the development of the ionic theory. His chief efforts were centered on the nature of the solutions of electrolytes, a problem growing out of the work of Arrhenius and proving to be the most outstanding physical-chemical problem of the period. His interest in this field was life long. In 1924, the year after Debye and Hückel announced their theory of solutions which takes into account the electric forces between ions, Noyes published an exhaustive review and extension of the derivation of the new equations.

Noyes's best known books are "A Course of Instruction in Qualitative Chemical Analysis of Inorganic Substances," "A System of Qualitative Analysis for the Rare Elements" (with William C. Bray as joint author) and, with Miles S. Sherrill as co-author, "An Advanced Course of Instruction in Chemical Principles." This last-mentioned book, known familiarly by generations of students as "Chemical Principles" will be remembered by all who have used it, for its exacting problems which form an integral part of the text. It is this book which embodies thoroughly Professor Noyes's method of instruction whereby students learn of the principles of science by using them in solving problems rather than just by hearing about them.

The more public services of Dr. Noyes brought him distinguished offices. He was president of the American Chemical Society in 1904, Acting President of the M.I.T. from 1907 to 1909, acting chairman of the National Research Council in 1918, and President of the A.A.A.S. in 1927.

Honorary degrees were conferred on Dr. Noyes by Clark University and by the Universities of Maine and Pittsburgh, each of which gave him an LL.D. Both Harvard and Yale made him an alumnus by granting him the Sc.D. In addition to membership in the American Chemical Society, the American Association for the Advancement of Science, the *Deutsche Chemische Gesellschaft*, and the *Bunsen Gesellschaft*, he was a fellow of the American Academy of Arts and Sciences, of the National Academy, and of the Philosophical Society, and a foreign associate of the Royal Society of Edinburgh. He was awarded the Willard Gibbs Medal of the Chicago Section of the American Chemical Society in 1915, the Davy Medal of the Royal Society of London in 1927, and the Richards Gold Medal of the Northeastern Section of the American Chemical Society in 1932.

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MAIL RETURNS

(Concluded from page 370)

stanza one learns from science through a prominent scientist everything about "the skies." — Miss Dickinson, not being scientifically inspired, could only guess. One learns a star's composition, its relative motion, its age. In the same way one learns from science a man's composition, his structure. And having learned all this from science one may still ask, in the words of the Psalmist, "What is man that Thou art mindful of him?" [1] and in the words of the Lord to Job, "Canst thou bind the sweet influences of Pleiades, or loose the bands of Orion?" [1]

Science is knowledge, art is wisdom. "There is a knowledge of natural things. But wisdom is an excellent gift of God."

The skies can't keep their secret.
They tell it to man's heart
Through every sense: "I wisdom am,
The beauty that is art." [2]

M.I.T., Cambridge.

[1] These are poetry; art, not science.
[2] This is verse; art, not science.

Retort

From PROFESSOR RALPH G. HUDSON, '07:

Professor Passano's comment on my article which appeared in the May Review contains too many misinterpretations and exaggerations to permit a detailed reply. In no place did I speak in generalization "of science as an inspiration of art." I did suggest that science "may be . . . a stimulus . . . to poetry." Sir Richard Gregory, editor of *Nature*, makes the same suggestion in a recent address on "The Interpretation of Science" and quotes Lucretius, Wordsworth, Milton, Dante, Goethe, Shelley, Tennyson, and many others in support of his contention. Kipling, in "M'Andrew's Hymn" says, "Lord, send a man like Robbie Burns to sing the Song o' Steam!" Hallowes has published a small book called "The Poetry of Geology."

I deny the imputation that our graduates who contributed to the fine arts "may well have been . . . round pegs that succeeded in pulling themselves out of square holes." Most of these men first demonstrated considerable ability in the field of science and engineering. It would appear that Professor Passano has little conception of the nature of the new electrical musical instruments. It is an injustice to all scientists working in this field to suggest that these instruments bear any resemblance to a hand organ.

It is true that we derive many impressions of beauty through the sense of touch. My original manuscript contained a paragraph on that topic which was deleted for lack of space. It is nevertheless a fact that the marble statue which the "connoisseur will want to touch" will have been shaped for the most part with a pneumatic drill. My article offered no suggestion that such statues should be produced endlessly "like 'gas pipe' suitings."

No prophecy was made or implied that "these, and all schools of painting, are now to be discarded." The camera has shifted the objective of the artist. His attention has already been turned to the development of new types of composition and new forms and patterns which the camera will find it difficult to duplicate.

It is quite evident that Professor Passano does not share my enthusiasm for the inspirational value of science. When the scientists at Mount Wilson look through their telescopes they learn more than "a star's composition, its relative motion, its age." They see more wonder, more grandeur, and more mystery than most poets can imagine.

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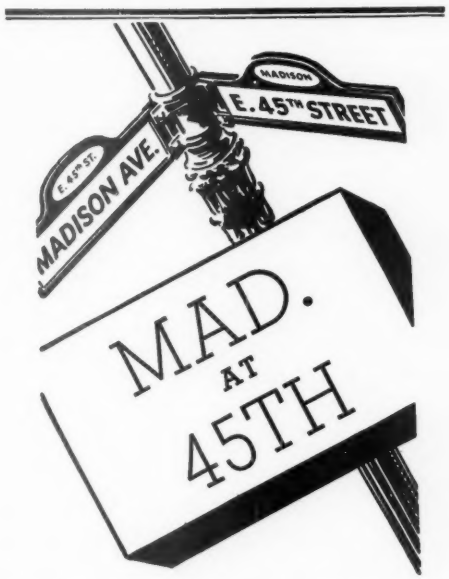

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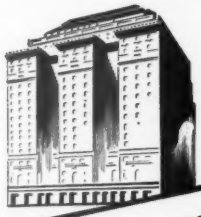

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EMPLOYMENT STATUS (as of June 1, 1936)	*Recipients Doctor's Degree*		*Recipients Master's Degree*		*Recipients Bachelor's Degree*		ALL GROUPS	
1936 GRADUATES	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Have accepted full time employment	*35*	*85*	*90*	*81*	*149*	*40*	*274*	*52*
Plan further study	*0*	*0*	*3*	*3*	*47*	*12*	*50*	*9*
Report good prospects	2	5	8	7	80	21	90	17
Without satisfactory prospects	4	10	10	9	100	27	114	22
Totals	41	100	111	100	376	100	528	100

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